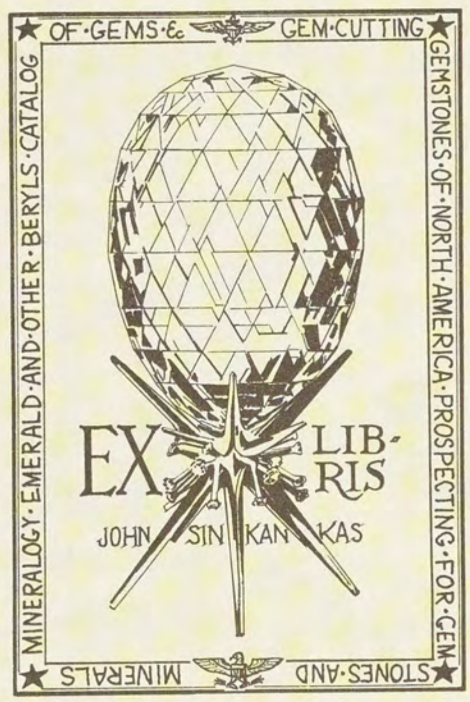
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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY,

ESTABLISHED NOVEMBER 13, 1807.

VOLUME THE SECOND.

Quod si cui mortalium cordi et curæ sit, non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant.

Novum Organum, Præfatio.

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Geological Society,
September 1, 1814.

ERRATA,

Some of which it will be necessary to correct, as materially affecting the sense of the passages, where they occur.

Page 9,	Line 14,	*for*	difficulty	*read*	difficultly
69,	 11,	——	iconocolasts	——	iconoclasts
152,	 4,	——	two chanels	——	one channel
163,	 21,	——	Pl. 9.	——	Pl. 11.
167,	 6,	——	found	——	formed
——,	 16,	——	has	——	have
169,	 9,	——	petrefactions	——	petrifactions
187,	 4,	*dele*	(;) after Agglestone		
213,	 14,	*for*	may	*read*	might
438,	 4,	*after*	Fig. 3 insert Plate 32, Fig. 1.		
440,	 6,	*after*	the word figures, insert Pl. 31, left hand figure at top.		

The Papers referred to in pages 475, 476, and 478, were intended to be included in the present volume, when those pages were printed: their publication has been deferred to the 3d Volume of the Society's Transactions.

In the list of Donations to the Collection of Maps, insert 12 Copies of a new Map of England, in 4 Sheets, from A. Arrowsmith, Esq.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY.

I. *On certain Products obtained in the Distillation of Wood, with some account of Bituminous Substances, and Remarks on Coal.*

By J. Mac Culloch, M.D. F.L.S.

Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich.

It is well known that when wood and other vegetable substances are submitted to destructive distillation, there is produced, among other matters, a black dense fluid resembling molasses or common tar. My connection with the Ordnance powder-mills having compelled me to examine some of the properties of this substance, which is obtained in large quantities in the process of making charcoal, I was induced to extend my enquiries, in consequence of finding that the nature of the compound has not hitherto been understood.

As it is commonly called *tar* by the workmen, I shall use this term for want of a better.

This tar is very inflammable, and so liquid that it may be burnt in a lamp.

Although it appears to be an uniform fluid, it contains a great quantity of acetic acid, in a state of loose combination or mixture. For, by washing with water, a great part of this is separated; the water at the same time acquiring a colour from a portion of the tar which is retained in solution by the acid. Boiling water takes up a larger portion, and the tar acquires from this operation a thicker and more pitchy consistence.

Lime and the carbonated alkalies separate the acid with ease, carrying away also a portion of the tar which continues united to the solution. With subcarbonate of potash it thus forms in the first instance an uniform solution of a brown colour, but a continuance of trituration or boiling renders it pitchy and tenacious, after which it forms no further union with the mild alkalies.

It is perfectly and readily soluble in alcohol, in ether, in the pure alkaline lixivia, in acetic acid and in the mineral acids. The fat oils and the new essential oils dissolve only a small portion of it; but the drying oils and the latter when thickened by age act more readily. Coloured oil of turpentine dissolves a good deal of it. Naphtha hardly exerts any action, acquiring a scarcely sensible brown colour. If heat be applied to assist the solution, the portion taken up is again deposited on cooling.

When it is subjected to distillation in a heat sufficient to keep it in a gentle ebullition, an oily looking matter passes over in considerable proportion, which sinks to the bottom of the water into which the tube is inserted. It is first of a pale colour, resembling oil of peppermint, but becomes gradually darker as the operation advances, till it acquires a deep brown hue.

If the operation be pushed by increasing the heat of the retort to redness, there remains at length only a mass of spungy charcoal, and the substance is totally converted into the following new compounds, namely, the residuary charcoal, the oily matter, and the matter held in solution in the water of the apparatus. This latter proves to consist of a large portion of acetic acid, with which is combined a very little ammonia.

There is no inflammable gas given out in this process unless the heat be carelessly managed. If the vapour of the oily matter as it arises be exposed to the sides of the retort elevated to a high temperature, it is decomposed, and instead of oil there are thus obtained by a violent distillation in a naked fire, scarcely any products but acetic acid and an inflammable gas. This fact is analogous to those occurring in the ordinary process for decomposing such inflammable bodies as can be made to put on the gasseous state—and we ought, in fact, to consider every process of this kind, where a rapid distillation with a hot fire is used, as a succession of decompositions; the matter first produced being afterwards exposed to another process of destruction. It is not therefore perhaps very correct language, to say that vegetables yield a great quantity of inflammable gas on distillation with a naked fire; this is the produce of a second distillation which by the common mode of operating is confounded with the first. As this reasoning applies equally to all other similar processes, it would be desirable to use a more accurate mode of describing this common operation by which we might in some important instances be led to a more correct practice. Thus, for example, in the common mode of distilling coal to produce the inflammable gasses, this double operation is carried on at once by the application of the petroleum and naphtha at first produced to the heated iron of the retort. It is in consequence of this imperfect mode of exposing the fluids thus generated to a second heat, that so large a portion of the petroleum is distilled unchanged. By causing it to pass a second time in contact with heated iron, while in the state of vapour, it may be resolved completely into inflammable gas and charcoal, and the produce of gas be thus considerably increased. This circumstance explains also the contradictory accounts given by different persons of the relative products of distillation, as applied to the various compound inflammables. To instance the case of camphor, which according to the mode of managing the process, may be caused to yield essential oil or inflammable gas or a mixture of both in various proportions. I need scarcely point out the advantages so obviously to be derived from this consideration in the œconomical process of procuring light from pit-coal, an operation at present conducted with less skill than it demands.

I distilled a portion of this tar in such a way as to obtain inflammable air only, and took the gas in five portions. The first burnt very faintly, the second rather better, the third and fourth portions with a good white flame, and the fifth burnt feeble and blue. No portion of it was equal in brilliancy of inflammation to the gas from pit-coal. On examination, it was found to contain much carbonic oxide, by which its nature, as far as it differs from the gas of coal, is readily understood. The cause of this difference will be apparent when the other circumstances in the constitution of this substance have been detailed. I thought it superfluous to examine accurately the nature of these gasses, but they probably consist of different mixtures of carbonic oxide, with light and heavy hydrocarbonate and olefiant gasses, if indeed, (as I much doubt) there be any real boundary by which the composition of these three last gasses can be defined.

If the process of distillation which I have now described be stopped when the oily matter begins to acquire a brown colour, and when the production of acetic acid is less perceptible, the matter in the retort will be found when cold, to have assumed a solid consistence. In this state it resembles either pitch or asphaltum, according to the degree of heat it has undergone after it became capable of solidifying.

I will describe this substance as it appears when it first becomes solid, the reason of which will soon be apparent.

Previously to its arriving at this state, it bears a considerable resemblance to maltha, being of a consistence intermediate between that of petroleum and asphaltum, but I did not completely examine its chemical properties in this condition because they appeared not to differ from what might be expected, and its history will be sufficiently full without it. In the solid state it is brilliant and shining and breaks with a conchoidal fracture and some external resemblance to obsidian. It has a pungent burning taste and the well known smell of wood smoke. It is heavier than the specimen of asphaltum with which I compared it, having a specific gravity of 1.254, while that of the asphaltum was 1.202. It is fusible and readily inflammable, burning with a white flame. It is electric and exhibits the same electricity as the resinous bodies. When heated in an open vessel, it smokes, and if kept in fusion till it ceases to smoke, it at length ceases to be fusible and is ultimately converted into a coal. During this progress it becomes more brilliant and less fusible, its fracture also from conchoidal becomes more splintery, and it puts on the appearance of asphaltum so accurately that the eye cannot detect the difference. Its specific gravity also diminishes, and its chemical properties vary in the way I am now about to detail.

I have described the perfect solubility of the tar in alcohol. The softest specimens of the pitch are nearly as soluble, leaving only a small residuum, which is infusible and powdery. The harder specimens become in proportion less soluble, and leave a larger residuum; and those which have been the longest exposed to heat scarcely give a stain to the alcohol, resembling in this respect the driest specimens of asphaltum. The analogy is here very apparent, for asphaltum may approach more or less to petroleum, and the various specimens of it are found to exhibit various degrees of solubility in alcohol. That which is least fusible in the fire, is, in both cases, the least soluble in alcohol. And by this consideration, the jarring accounts which have been given of the solubility of asphaltum in alcohol may be reconciled, and it will be seen in the sequel, that the history of this substance illustrates, in every respect, the true nature of the several varieties of the bitumens, substances whose mutual relations, and the causes of whose chemical diversity have hitherto not been understood.

If a perfectly soluble specimen be dissolved in alcohol, it is obtained unchanged by evaporating the spirit. In any other case, the matter which the alcohol has taken up is precisely similar to the pitch in its first state, and the residuum resembles that which is the result of fusion when it refuses longer to melt. Alcohol therefore separates the pure pitch from that, which by a process of decomposition has been nearly carbonized. Ether acts upon this substance as readily and in the same manner as alcohol does. In lixivium of pure potash it is more completely soluble than in alcohol, and forms with it an intensely brown solution which is diffusible in water without change, and which, on the addition of an acid, deposits the matter in a powdery form and apparently unchanged. It is also soluble in water of ammonia with similar appearances. It is scarcely soluble in the pale oil of turpentine, but more readily in the darker. It is slightly soluble in the fat oils, in tallow and in wax, but is considerably more soluble in drying oil. In all these cases its solubility varies, from the same causes as those which affect its solubility in alcohol. Naphtha, whether pale or brown, has no action on it when cold and takes up but a very minute proportion even with the assistance of heat. It fuses into an uniform mass with sulphur, with resin and with asphaltum.

Acetic acid, which dissolves so many of the compound inflammables, effects a compleat solution of it and in large proportion, and this compound is precisely similar to the empyreumatic acid as it proceeds from the iron retorts in which the charcoal is distilled. It would be desirable in an œconomical point of view, to discover a method of freeing the acid from the pitch. After many trials, by combining the foul acid with various bases and again separating it, it was always found to retain the overpowering smell of wood-tar. If the acid is combined with the pitch at a high temperature, a large proportion of it separates in the form of tar on cooling. Muriatic acid, after long boiling on the pitch, became brown and dissolved a little of it.

By digestion with sulphuric acid it was dissolved forming a brown oily looking fluid, sulphureous acid being at the same time disengaged. By dilution with water, a smell resembling peppermint was produced, as happens in a similar case with camphor, and the pitch was thrown down. The action of the red nitrous acid on it is violent; the acid is decomposed with great ebullition and a portion of the pitch is converted into coal. In diluted nitric acid it dissolves and produces an uniform brown fluid. On continuing to apply nitrous acid according to the process of Mr. Hatchett, solutions similar to those which he has described as having been obtained from the resins and bitumens, are produced.

I exposed a quantity of the pitch to a careful distillation through water. As might be expected from what I described before in the distillation of the tar, this process gave results nearly similar to the former. The oily matter differed in being of a brown colour and in having a greater specific gravity, and much less acid was produced; the residuum was charcoal. The whole process of distillation appears, therefore, to be a decomposition by which the pitchy substance is converted into oil, acetic acid, ammonia and charcoal.

I proceeded next to examine the oil. It has a violently pungent taste and smell. It is scarcely heavier than water; so that it sinks in that fluid with difficulty, leaving generally some drops on the surface. It is perfectly soluble in alcohol, in ether, in caustic alkali, in olive oil, and in linseed oil. It will unite neither to naphtha, nor to the recent essential oils, but is soluble in the old ones. From these properties, it belongs to the class of the essential oils, but exhibits at the same time other qualities by which it is distinguished from the whole of them.

Having thus examined the most remarkable chemical properties of this substance, it will not be irrelevant to point out its differences from and its analogies with those substances which it most resembles, namely resin and the bitumens. Resin, as is well known, is eminently soluble in all the substances in which this is dissolved, and also in those with which this refuses to unite, even naphtha. But the general analogy between essential oil, turpentine and resin, is so close to that of the three substances which I have described, that it will not perhaps be superfluous here to make some remarks on the nature of common resin and the substances connected with it, pitch, tar, turpentine and essential oil, as their history will also illustrate that of the substance I am describing, and as it appears, like that of the bitumens, to have been somewhat mistaken.

If turpentine, as it flows from the fir in a liquid state, be exposed for a considerable time to the action of the atmosphere, it becomes brittle, and is converted into resin, in consequence as it is supposed of the absorption of oxygen. If the same turpentine be exposed to the action of the fire, a colourless volatile oil is separated, and resin remains in the retort. This however is not a mere case of the separation of a more volatile from a fixed substance, for a decomposition takes place, and acetic acid is generated. Nor can turpentine be again reproduced by mixing together the essential oil and the resin—it then forms a varnish. The essential oil is in fact a new compound, produced from the vegetable elements by the action of fire; and although properly enough classed with those essential oils which are vegetable secretions, differs from them in some of its chemical properties. It is, for example, difficulty soluble in alcohol, but on exposure to air it becomes thick and yellow, and is then easy of solution in the same substance.

If the resin, which is the residuum of this distillation be still further heated, it gives over a thick and high coloured oil, gradually increasing in weight, till it equals, and at length exceeds the specific gravity of water. The residuum becomes ultimately black, and very brittle, remaining soluble in ether and in lixivium of potash, but refusing to dissolve in alcohol.

Common tar differs from turpentine in containing a portion of the vegetable tar now under review, mixed with common turpentine and with the acetic acid which is formed in the distillation to which the wood is subjected for the purpose of obtaining it. Evaporation converts this into pitch, by decomposing it.

In this process, an essential oil, compounded of the oil of turpentine and the oil of wood, together with a portion of acetic acid, is separated, and the residuum or common pitch, is a compound of resin and the wood pitch which I have been describing. To this admixture, and not to that of adventitious charcoal produced in combustion, is the black colour of common pitch owing.

The analogy between this wood pitch and the bitumens is equally striking, and the preceding history of these compounds will throw light on the several varieties of the bituminous substances.

Assuming the tar as the medium form, it is seen that when exposed to heat it gives over oil, and that pitch remains. Thus, petroleum yields naphtha and asphaltum; and thus too, asphaltum exhibits all the gradations which I have described in the pitch, its properties varying in a similar manner, according to its particular state. In the process of distillation the principal difference will be found to consist in the relative quantities of acetic acid and ammonia, which they severally yield; the former chiefly characterizing the wood tar, and the latter the petroleum. From the same chemical cause which produces this effect arises also the difference in the nature of the inflammable gasses which are produced from these different substances.

The sensible qualities of the bitumens (their taste and smell) are in all states utterly and entirely different from those of the vegetable tar. Petroleum is also much less soluble in alcohol, and further differs from the vegetable tar in being perfectly soluble in naphtha. In their solubilities in oil of turpentine they resemble each other, as well as in their habitudes with acetic acid and the alkaline lixivia, although the vegetable tar will be found the more readily soluble of the two. I need not repeat the circumstances in which the essential oil of wood differs from naphtha. It is a sufficiently characteristic one, that it forms no union with this latter.

It has been already shown that the difference between the pitch and asphaltum is considerable, when the former is in its first state, particularly with regard to its solubility in alcohol.

But if we compare the most brittle specimens of the pitch with common specimens of asphaltum, the differences, except as far as smell and taste are concerned, are not so apparent, and the reason of this will be obvious on considering their fundamental similarity of composition. The chief ingredients of both are carbon and hydrogen. By the application of heat, the proportions of these substances are altered in both cases, the hydrogen being abstracted in the greatest ratio, to form the new compound (the oil) in which hydrogen predominates. The ultimate result of both is charcoal. Asphaltum will be found to combine pretty nearly in the same way, with all the substances I have above enumerated as combining with the pitch. Its essential difference however consists in its solubility in naphtha, and by this test they are readily distinguished.

The chemical difference to which these different properties of substances so similar are owing, will be evident on considering some of the circumstances before related. The disproportion of acetic acid and carbonic oxide produced from the wood pitch, when compared with the produce of the bitumen, proves that it contains oxygen and azote in proportions different from those in which the same substances exist in the bitumens; and that in particular it contains a considerable quantity of the former. The result would not repay the toil required to investigate these proportions, which are probably also subject to considerable variation.

It is obvious that this substance is a new compound, formed by the action of fire on vegetable elementary matter; but all that we can determine of its nature is, that in conformity to modern chemical nomenclature, it is formed of carbon, hydrogen, oxygen, and azote. The carbon and hydrogen constitute its basis, as they do that of the bitumens, and the large proportion of oxygen appears to give it the peculiar properties by which it is distinguished from them.

It seems evident however, that no very great change is wanting to convert the one of these into the other.

The question so much agitated, of the conversion of vegetables into coal, would appear to receive some illustration from the history of the compound which I have been describing, and since (as I shall by and by show) it has actually been confounded with bitumen, and has been adduced as an instance of the artificial production of coal by the action of fire, I shall make no apology for pursuing this subject. Indeed the general chemical resemblance between the mineral bitumens and this vegetable bitumen, if it may be so called, is so striking, that we may, at first sight, be easily led to suppose that the same agent has produced both, and excuse the mistakes which seem to have occurred on this subject. But a cursory view of the several substances which have been classed under the head of bitumens, may enable us to form a clearer notion of the limited extent of this analogy, at the same time that it will perhaps assist us in correcting some errors which have crept into our arrangements of them.

It is necessary to separate from the bitumens three or four mineral substances, which differ completely both in chemical and ordinary characters, but which are approximated to each other by some general resemblance. These are, amber, mellilite, and the subterraneous resins of Cologne, Bovey, and Highgate. The two first are more nearly associated by the property they have of yielding a peculiar acid; and of the three last, it may perhaps be fairly doubted, whether they are more entitled to be ranked among the mineral substances strictly so called, than the other vegetable matters which are found in alluvial soils.

The nature and relations of naphtha, petroleum, maltha, and asphaltum, will, I trust, appear sufficiently clear from what I have above related, but I cannot forbear remarking on some false hypotheses which have been held respecting these substances, and their relation to other bodies. It is evident, from considering the products of their decomposition, that the basis of naphtha and of all the intermediate stages of bitumen, down to asphaltum, are carbon and hydrogen, modified by certain small proportions of oxygen and azote. It is in the relative proportions chiefly of these two ingredients that naphtha differs from petroleum, petroleum from maltha, and maltha from asphaltum. If we distill either of these more solid substances with a very gentle heat, we obtain naphtha, in which the proportion of the hydrogen to the carbon is increased to a maximum ratio. If the heat is greater, we obtain a substance of a darker colour, in which that ratio is less; and, for this reason, the distillation of asphaltum affords a darker oil than that of petroleum, because its composition cannot be dissolved but in a higher temperature.

For the same reason also petroleum is easily rectified into naphtha. Asphaltum, in its ordinary state, contains the two ingredients in a ratio in which the carbon bears a large proportion to the hydrogen, and that ratio is reduced to the minimum, or becomes evanescent, when by the continuance of distillation, charcoal alone remains behind. A large portion of the oxygen, and also of the azote, is disengaged during this process, but not the whole, since the darker compounds still give it over on repeating the process. The naphtha is probably entirely exempt from oxygen. With this view we cannot accede to the notion, that the absorption of oxygen is capable of converting naphtha or petroleum into asphaltum; or that the harder bitumens originate from the oxygenation of the more liquid. It is more consonant to the nature of these substances to suppose, that the change consists in the alteration of the relative proportions of the hydrogen and carbon, but whether this is performed by the action of heat, or of other causes volatilizing the hydrogen, or by the contact of oxygen converting it into water, cannot now be determined by any facts that we are acquainted with. Experiments on the induration of the essential oils may throw some light on this question. It will here perhaps be remarked, that there is a difference in the substances as they are produced artificially by the distillation of coal, and as they are found in nature. Thus, for example, the artificial petroleum of coal differs from that of nature, in being much more soluble in alcohol. Yet, this circumstance may arise from the insensible gradation of difference which I have above remarked in the similar compounds, and thus in the series of gradation, specimens absolutely corresponding, whether artificial or natural, may exhibit the same chemical characters.

Thus, as I have shown that there is a sort of gradation from naphtha to asphaltum, through a series of undefinable petrolea, so this analogy may be extended to the next general variety of the bitumens, coal.

The several varieties of coal are supposed to consist of charcoal and asphaltum, or of charcoal and bitumen, combined in as many different proportions. Charcoal is undoubtedly found mixed with coal, but it does not appear correct to consider pit coal as either a mixture or combination of any bitumen with charcoal. The action of naphtha on its varieties, often none and always sparing, shows that bitumen does not exist in it in a mixed state. It will be more consonant to the analogies of the other bituminous substances, to consider coal in its several varieties as a bitumen, varying in its composition, from the fattest specimens of Newcastle to the driest of Kilkenny, and owing its compactness, as well as the other modifications which it exhibits, to the peculiar circumstances under which it has been formed, the changes it may subsequently have undergone, or the substances with which it has accidentally been mixed. The power of yielding naphtha on distillation, is rather to be resorted to as the distinction between the one end and the other of the series; and it would be surely equally correct to call coal a compound of charcoal and naphtha, as a compound of charcoal and asphaltum.

Its several varieties will moreover be found to vary from each other by containing greater or less proportions of carbon, compared with their other ingredients; just as in asphaltum the relative proportions of the hydrogen, azote, and oxygen, to the carbon, are found to differ from those which constitute petroleum or naphtha.

The last link of the chain of coal (chemically considered) is anthracite, which contains only carbon, if we reckon the earths mixed with it as adventitious matter. So the last result of the distillation of asphaltum is charcoal, and the intermediate steps through which asphaltum passes in its progress to charcoal, resemble precisely the corresponding changes which occur in the distillation of coal till coak is formed, and confirm by their chemical analogy the view here held forth of the chemical composition of coal, and the gradation to be traced in nature from fat coal to anthracite. If asphaltum be subjected to distillation it gives petroleum. By degrees its solubility in naphtha diminishes, in consequence of its carbonaceous ingredient becoming more disproportioned to its hydrogen. At a particular period of this distillation it will be found to resemble fat coal; by and by, it resembles blind coal, and gives no stain to naphtha; ultimately, pure charcoal remains. All these bituminous compounds may therefore properly be said to belong to one genus or family, of which the principal chemical ingredients are carbon and hydrogen, and it is chiefly to the difference in the relative proportions of those two substances that we are to look for the differences which characterize the several bitumens, from naphtha placed at one extreme, to anthracite placed at the other. The chasm in this series from asphaltum to fat coal, is in fact, rather apparent than real, being more properly a mechanical or accidental, than a chemical or essential one. I cannot here avoid taking notice of the very loose experiments of Mr. Kirwan on the analysis of coal, (which consisted in projecting portions of coal on melted nitre) as his deductions are at war with this view of the subject, although not more so than with all chemical reasoning. They were founded on an assumption, that coal was carbon impregnated sometimes with maltha and sometimes with asphaltum—a distinction quite unnecessary if the supposition were true. If we conceive coal to be compounded in this way, it would be more obvious to consider it as formed of carbon and petroleum, since by a regulated heat it can be separated into those two substances. The theory of the experiment is equally assumed and the conclusions equally groundless, when it is inferred that of this compound, (coal) the carbon alone possesses the power of decomposing the nitre, and that the proportions of these supposed ingredients may thus be determined. The varying temperature of the nitre, would necessarily produce considerable variations and uncertainty in its action, and in the consequent accuracy of the results; but it is plain, that the effect of this contrivance was to separate by a sort of distillation the petroleum which fire elicits from coal, and that the method could neither be so accurate as that of ordinary distillation, from the greater irregularities to which it was subject and the difficulty of conducting it, and that it proves nothing with regard to the composition or nature of coal. In the examination of maltha, and asphaltum, the defect of this method is still more apparent. If heat and flame be applied to these bitumens, with access of air, they are either consumed without leaving any carbon, or that carbon which there is not oxygen enough present to burn, is deposited in a state of very minute division in proportion as it is volatilized, during the formation of the naphtha or petroleum, the more hydrogenous part of the compound. But if this part is separated without flame, either by a more moderate heat, or by excluding oxygen from it, the carbon is rendered apparent by its affinity of aggregation, which causes it in the end to assume comparatively refractory powers, and a more solid form.

Such are the views I would entertain of the bituminous genus, in which as it is found in Nature, all traces of organization or resemblance to vegetable and animal inflammable matter, have so thoroughly ceased, that we are entitled to give its several species a fair rank among minerals. But there is yet another division of inflammable and subterraneous substances connected with these, of which the claims may appear doubtful. Retaining as they do, the traces of organization, and that sometimes in great perfection, it may be often questioned whether they do not more properly rank with the fossil remains, than with the minerals properly so called. They are well distinguished by the name of Lignites. At one end of this series is placed jet, in which the traces of vegetable origin are nearly obliterated. Surturbrand and the several varieties of brown coal, including Cologne earth, connect it gradually with submerged wood and peat. The experiments I have already related prove that the substance resembling bitumen, which is produced by the action of fire in the ordinary way on vegetables, differs from it essentially, and it has been seen that solubility in naphtha is the readiest criterion by which these substances can be distinguished. To assure myself of the accuracy of this test I mixed the petroleum of coal with the black oil of wood in several proportions, and by the application of naphtha separated the one from the other. By this simple method therefore I expected to detect not only the progress of bituminization from simple turf to jet, but to assure myself whether in the examinations hitherto made by others of these different substances, any mistake had arisen from confounding the vegetable bitumen with true bitumen when distillation was used to investigate their nature.

Vegetable turf in all its varieties, as well as brown coal, gave a considerable colour to lixivium of potash, but the same menstruum produced no effect on jet, or surturbrand. Nor had naphtha or alcohol any action except on the resinous lignite of Bovey, from which they extracted the resinous matter which that variety contains.

I therefore subjected these different substances to distillation, trusting that by the produce, I should ascertain, not only the fact, but the progress of bituminization.

Submerged wood, from peat mosses in Cumberland, gave a brown oil, smelling of the wood tar and refusing to dissolve in naphtha. In this case therefore, no appearance of a change towards bitumen was exhibited. A compact pitchy looking peat gave an oil which had a fetid smell, neither resembling that of wood tar, nor bitumen, and which was very slightly soluble in naphtha.

The Bovey brown (board) coal, produced an oil of a peculiar smell, but most resembling that of wood tar, and much more soluble in naphtha than the preceding. Having a larger quantity of this, I separated the soluble part by naphtha, and in the remainder, or insoluble oil, the smell of wood tar was powerful, notwithstanding the strong odour of the naphtha. Here then the progress of bituminization had advanced another step. The resin of this wood, on which a particular name has lately been bestowed, I consider as an adventitious and accidental substance, and the natural produce of the tree, now probably unknown, which occupies these alluvial strata, as other lost productions of Nature are detected in other alluvial soils.

A specimen of black lignite from Sussex gave an oil which resembled the former in smell, and perhaps did not differ much from it in its solubility in naphtha, but I had not enough of the substance to institute an accurate comparison, neither in fact, could it serve any purpose. A similar substance from Bovey gave similar results.

The oil which was distilled from jet was of a greater specific gravity than any of the preceding, and smelled strongly of petroleum. It seemed to be soluble in naphtha as readily as the specimen of petroleum with which I compared it. Indeed had it not been that a greater quantity of acid was given over in this process than from any of the varieties of coal, I know not that any chemical distinction between the two would have existed. The mineralogical one is still considerable. The several specimens above enumerated, yielded each a large portion of acetic acid, marking as clearly as the peculiar sort of oil did, the remains of unchanged vegetable matter.

Examining therefore the alteration produced by water on common turf, or submerged wood, we have all the evidence of demonstration that its action is sufficient to convert them into substances capable of yielding bitumen on distillation.

That the same action having operated through a longer period has produced the change in the brown coal of Bovey, is rendered extremely probable by the geognostic relations of that coal. From this to the harder lignites, surturbrand and jet, the transition is so gradual, that there seems no reason to limit the power of water to produce the effect of bituminization in all these varieties, nor is there aught in this change so dissonant from other chemical actions, as to make us hesitate in adopting this cause. In the ordinary process of vegetable putrefaction and destruction, a variety of compound gases are formed by the reaction of their elements, and carbon alone, or rather carbon united to a portion of hydrogen, remains behind.

Here the oxygen is completely dissipated, together with the azote, and the greater portion of the hydrogen. Analogous circumstances determine the putrefaction of animal matter, but in this case the play of affinities is so intricate, that a large portion of the carbon is volatilized in the gaseous form. By the constant affusion of water however, this process may be so modified, that the greater part of the hydrogen and carbon will be retained, and enter, together with minute portions of other gases, into a new compound resembling fat, which has obtained the name of adipocire. The analogy is strong, and the gradual deoxydation of the wood in this process is visible in the different stages of bituminization.

Such, as far as observations have yet gone, is our knowledge of this process and of the power of water in producing it. To repeat such an experiment in the laboratory seems impossible, since the necessary element of time must be wanting to complete it. But the action of fire being of shorter duration, and affording us also readier means of imitating Nature in those operations in which she has wrought with the same agent, it is worth our while to consider, if by it we can produce from vegetables the bituminous matters under review. It is not necessary to say how intimately this question is connected with our speculations on the origin of coal, since Sir James Hall's experiments were expressly intended to illustrate this view of the subject. In this, it is related that " coal" was produced from " fir saw dust" by the usual method employed in these experiments, and that pieces of wood were changed " to a jet-black and imflammable substance, generally very porous," in some specimens of which " the vegetable fibres were still visible." There is no reason to doubt that the substance produced in these experiments, was that black matter which I have described in the first part of this paper, which, however resembling bitumen in colour and inflammability, I have proved to be a different substance, and that the igneous theory of the origin of coal will receive no support from them, as far at least as relates to the conversion of vegetable matter into bitumen. I need take no notice of the modifications derived from a mixture of animal matter in these experiments, as it is not my desire to enter into a discussion of the general question, but to state such chemical facts as arose in the experiments I undertook. And since it is certain that vegetables alone are competent to the production of bitumen, and that the geological history of coal does not justify a supposition that animals have been concerned in its production, it is perhaps unnecessary to investigate that question further.

To satisfy myself whether any essential chemical difference would result from the experiments performed by simple heat, and those performed by heat under pressure, I repeated these trials, by heating wood in close gun barrels, introducing occasionally lime, clay, or other matters to absorb the acid generated, and give the greater chance for the disoxygenation and bituminization of the wood. But the produce only differed from that of the experiments in open vessels, by the circumstance which is mentioned in Sir James Hall's paper, namely, the mixture of a porous charcoal, or a half destroyed vegetable structure. In all cases the bituminous looking matter was vegetable tar, not bitumen.

Thus far then perhaps we are justified in concluding that the action of water, and not that of fire, has converted the vegetable matters into bitumen. It is another question to determine how that bituminous matter in its several forms of peat or lignite, has been converted into coal, into a substance differing mechanically, rather than chemically from it, if, without misleading, I may use the contrast of these terms.

There is a wide interval between the external characters of the lignites and of coal, and though we cannot presume to state the period which Nature has used in her operations, nor during how long a space the causes have continued to act, before the vegetable matter has undergone its ultimate change into coal, nor therefore whether the long continued agency of water and pressure may not have produced the required changes, yet, since Philosophers of high reputation have supposed that fire has been a probable cause of this conversion, and that this theory is supported by considerable evidence in some analogous cases, it is our duty to examine by experiment, what effects conducing to this end may result from our limited trials. The foregoing experiments show that the fire of our furnaces does not convert wood into bitumen, and the processes of Nature seem to prove that water can produce this effect, and that jet, the bituminous lignite which approaches nearest to coal in its chemical characters, is the result of this action. Yet there is an interval between jet and coal as I have already observed, requiring explanation. The chemical characters may be identical, but the mineralogical resemblance is still wanting. It is possible that the agency of fire may account for this ultimate change, and that its action on beds of lignite and peat has converted not wood but vegetable matter already bituminized by water into coal. Pursuing this train of investigations I was induced to try if jet, the most perfectly bituminized lignite, could by the application of heat under pressure be converted into coal. For this purpose I introduced powdered jet into gun barrels, placing it between two portions of rammed Stourbridge clay, with the view of absorbing a part of the distilled petroleum when it might be formed in greater quantity than was requisite for the success of the experiment, and where by its conversion into hydrogen, it might endanger the bursting of the apparatus. The barrels, which were Swedish, were held in a moderate red heat till they burst, when they were instantly withdrawn and cooled in water to prevent the further volatilization of the bituminous matter. As the opening was generally no larger than a pin hole there was no difficulty in cooling the apparatus in time. In this way, among some failures, I procured a perfect fusion of the jet, which exhibited the true characters of coal, and was taken out with the impression of the irregularities in the barrel. I need not add that in this case the produce had not merely the colour and inflammability but the fracture of coal and its odour on burning. It is not unlikely that by a sufficient repetition of these experiments with better regulated heats and more leisure than I possessed, several varieties of coal might have been in this way produced. Indeed some of the specimens exhibited a dry, and others a fat appearance, but it was impossible in general to detach them from the barrels without reducing them to small fragments. Two other circumstances occurred deserving of notice. In one or two cases where the heat had been too great, a portion of the jet was reduced to charcoal, which continued attached to the coaly matter, and the clay was in every instance blackened to a considerable distance from the jet, and converted into a hard compact substance resembling bituminous shale in its smell and consistence.

Reverting to the chemical nature of the other lignites, there is very little reason to doubt that those among them which approach the nearest to a state of perfect bituminization, would have given results nearly similar, but I could not pursue the investigation for want of sufficient specimens. From peat we should expect but a mixed matter, varying between the bitumen of wood and true bitumen, according to the degree of change previously undergone; for that the process of bituminization is the effect of water, and not of fire, is rendered probable, as much by these trials as by the geological observations above mentioned. The conversion of bituminized wood into true coal may possibly be the effect of a consolidation produced by the agency of fire, but I shall leave this argument in the hands of those who have undertaken the defence of this theory—having entered into this train of reasoning, not by design, but from the unavoidable concatenation of experiments.*

A circumstance occurred in the coaly residuum of the wood tar which it is worth while to notice, although of an accidental nature, and not essentially affecting the history of the vegetable bitumen or pitch which I have described. It bore no resemblance to common charcoal, but was more like black lead. It was as glossy, and although not so soft, marked paper with a similar streak. It was inflated, and therefore minutely scaly, and porous, and was attracted by the magnet. Muriatic acid took up a portion of iron from it, as it does from many varieties of plumbago, and the remainder resembled plumbago after it had been submitted to the action of acids.

* That I may not interrupt the text, I will add, in a note, a cursory account of the black matter which is deposited in bogs, and which seems to be the substance giving the pitchy appearance to the more compact varieties of peat. I have not seen it in the soft state in which it is first procured.

When dry, it is black, sometimes dull, sometimes with the lustre of asphaltum. It is heavier than water. It is not electric. It is brittle, and breaks with a fracture intermediate between the splintery and conchoidal, resembling asphaltum generally in its external characters. Exposed to a red heat it is incinerated, giving a smoke possessing a modified smell of vegetable (pyroligneous) acid. It is not acted upon by boiling alcohol, ether, or naphtha; and in this latter circumstance, its difference from asphaltum is marked. Neither is it soluble in boiling water. It is readily dissolved in lixivium of potash, and by nitrous acid. It appears to be formed of the vegetable elements in the state of transition to bitumen, the carbon having been first held in solution, as it is in the water of dunghills, by the other matters with which it was combined, and being at length consolidated by the dissipation of a portion of them. The produce of its combustion shows it is combined with both hydrogen and oxygen.

It was also exceedingly difficult to burn, requiring a long continued red heat, after which it left an oxide or rather a carbonat of iron, such as remains from the combustion of plumbago. It is in fact to be considered as an artificial plumbago, a substance of whose nature all the charcoals of difficult combustibility partake, deriving their resemblance apparently from the same cause.

The formation of this plumbaginous substance serves to shew a very powerful affinity between iron and carbon, even where the proportions are very different from those which enter into the composition of steel. But to effect this combination, it is necessary that the carbon be in a state of previous union with other substances, and that it be applied to the iron in that state. It will be in vain that we attempt to combine iron with charcoal for this end, unless the charcoal or carbon be in that state of very minute division in which it exists when precipitated by a new affinity from some previous combination.

It is necessary now to account for the iron in this compound.

This distillation of wood for charcoal is carried on in iron vessels, and hence is derived the iron which enters into the composition of the pitch. I will not say that it is solely derived thence, as it is probable that if there were iron contained in the vegetable matter, it would also be found in the same place. When the acetic acid has been separated the iron remains united to the pitch. This fact may shew us, that if in the destructive analysis of vegetable (and probably animal) matter, we trust to find the iron they may contain in the residual matter of the distillation, we may be disappointed, since it may be carried over, together with the substances I have now been describing, in the act of ebullition, as happens in this very case, its tendency being to combine with them, in preference to the charcoal.

As it was no part of my design to examine the vegetable elements, I did not pursue any experiments with this substance distilled in earthen vessels so as to ascertain whether in this case also it would contain iron, but I did enough to satisfy myself that the pitch was essentially the same in which ever way produced.

It is already known that a substance resembling plumbago is formed in water, it having been discovered by Fabroni in the country round Naples. It is equally known to be formed in the iron foundries, and the advocates for the igneous origin of coal have also contended for that of plumbago, and have supposed it to have been produced by the contact of melted greenstone with beds of coal. But even if we admit this cause of its formation, something else seems necessary for the production of the substance, and some other mode of applying the heat required before it can be produced. Nor indeed does the explanation sufficiently correspond with the general geological position of plumbago.

In numerous trials to combine iron with charcoal so as to form this substance, I have uniformly failed of success, except where as in the case above related, the charcoal or carbon has been in a state of previous combination, or was actually held in solution. In many trials on this principle, the results have been tolerably successful. If therefore we are to adopt an igneous theory of the formation of plumbago, it will be as easy to suppose that the action of subterraneous fire on mixtures of bitumen and iron has produced the compound of charcoal and iron, on the principles I have described, and this supposition will be more consonant to the chemical facts. But we are too little acquainted with the geological relations of plumbago to lay much stress at present upon this or any other hypothesis. It is evident that plumbago may be a produce of art, and could it be produced in as solid and compact a state as Nature affords it, the discovery would form a material addition to those useful ones for which the arts have been indebted to chemistry.

As nothing tends more to confusion of ideas than confusion of terms, I may be excused for proposing a name to the pitch of distilled wood, a name in familiar use, though hitherto unappropriated by chemists. It is in fact that which is well known to painters by the name of *Bistre*, although the nature of bistre has I believe never yet been examined; and the importance of it to the arts of design induces me to extend this article for a few lines. According to Dr. Lewis, bistre is produced from the soot of all wood, other receipt books give us the same account, but limit the sort of wood to beech without seeming aware of its real nature; but the colourmen use the soot of all wood indiscriminately.

Those artists who have made the tour of the highlands of Scotland, are well acquainted with that variety of it which varnishes the interior of a highland cottage.

In all these cases it is a very variable article, and the colour-maker being unacquainted with its real nature, is unable to rectify its faults, in consequence of which it is often unfit for use, notwithstanding the various operose and mysterious purifications it undergoes in his workshop. The causes of these varieties will be very evident to those who have read the foregoing experiments. An imperfect separation of essential oil and a consequent tenacity arising from its too near alliance to the tar, will appear to be its most common vice, and it is this which gives it that disagreeable gumminess and disposition to return to the pencil which is destructive of its best qualities. At times also from the same causes it is offensively yellow. So valuable is a brown colour that will work freely and with transparency, that the artists will be much obliged to him who shall render bistre equal in freedom and force to seppia. By distilling or evaporating the oil from the pitch, according to the process described above, a colour may be produced varying in tone from the warmest bistre brown down to black. At the same time the substance loses a great portion or the whole of its disagreeable tenacity, according to the degree of boiling it has undergone. By treatment in alcohol, results in some measure similar are produced, and the residuum of this solution is equal in colour to seppia, and totally void of tenacity. In either or both of these ways may the quality of this colour be improved.

It might perhaps be a matter worthy of trial, whether useful varieties in colour and quality might not be produced by the distillation of different woods. That which I used was procured either from willow or alder—the two woods chiefly used in the royal powder mills, but I cannot ascertain from which of them. The solution in lixivium of potash or of soda, a substance analogous to the resinous soaps, answers the purpose of ink, possessing a colour sufficiently intense and flowing freely from the pen without requiring gum. As it is indestructible by time, by the common acids or by the alkalies, perhaps it may be found a valuable substitute for this useful but fugacious substance. The compound of bistre and soda appears peculiarly well fitted for drawing in monochrome, since as it does not consist of a powder suspended in a vehicle, it is free from the peculiar defects, so well known to artists, which occur in colours thus compounded.

I may also add that it forms a substitute for asphaltum in drying oil where such a coloured varnish is wanted, and that it makes a very good japan varnish for metal if dissolved in spirit of wine, and heated strongly after its application. It is for practical men to see whether by combining it with asphaltum, lac, or the gums, some more useful and cheap compounds of this sort may not be produced.

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II. *Mineralogical Account of the Isle of Man*,

By J. F. Berger, M.D. M.G.S.

INTRODUCTION.

THAT the name of the Isle of Man should be owing to its situation, does not appear at all improbable. Such is the conjecture of the learned Bishop Wilson in his short but valuable "History of the Isle of Man."

The appellation of the island, says that respectable prelate, is probably derived from "the Saxon word *Mang*, among, as lying almost at an equal distance between the kingdoms of England, Scotland Ireland and Wales." *

With the exception of the work just mentioned, we scarcely find in the tours that have since been published any information directly bearing on the mineralogy and physical structure of this island till we come to the late publication of Mr. Geo. Woods, where indeed these topics are more fully detailed than is usually the case in general topographical descriptions. †

In enlarging upon the same subject, I hope that I shall not occupy in vain the time and attention of the Geological Society: for

* Bishop Wilson's Works—Second Edition—Two Vol. fol. Lond. 1782. Vol. I. p. 449.

† An Account of the Isle of Man, by George Woods, London 1811.

a minute investigation both of the rocks and simple minerals had never been yet instituted, and the arrangement and examination o the *high land*, the most conspicuous and extensive part of the isle, still remained a field quite unexplored.

The grotesque and unfaithful attempt of Fannin to lay down the mountains in his map of the island published in 1789, can hardly be considered as an improvement upon the much earlier and rough sketches of Collins, Durham and Speed.

From the materials and documents which I collected when in the Isle of Man, I have since my return from Ireland constructed a map chiefly expressive of the features and appearances of the mountainous tract, which I now present to the Society; acknowledging at the same time the able and kind assistance afforded me by Mr. Webster, draughtsman to the Society.*

The height of Snei-feldt was a long time ago determined by means of the barometer, by Bishop Wilson, † and it has been since

* This map however is neither complete nor as perfect as I wish I had been able to execute it. Mr. Wm. Geneste (a gentleman of Douglass, to whom I am much indebted) has had the complaisance to undertake last Summer at my request, a trigonometrical survey of the Isle of Man, conjointly with Mr. James Kewley, a person who has formerly practised as a Surveyor. But I fear the result of their labours, which Mr. W. G. intended with a great liberality to put at my disposal, will not be ready to be published in this volume of the Transactions of the Geological Society.

† The height of *Snafield* (says the Bishop) as taken by an exact barometer, is about five hundred and eighty yards, the mercury subsiding two inches and one tenth. Vol. I. p. 449.

This is very probably the first application that was made of the barometer in Great Britain to determine the elevation of a mountain.

The original experiment pointed out by Pascal, was performed by Perier (his brother-in-law) on the "Puy de Dome," 19th Sept. 1648. Bishop Wilson came over to the Isle of Man in April 1698, where during his long residence, he made the experiment that led him to the elevation of Snei-feldt.

included along with that of North Bor-roilva, in the trigonometrical survey of England by Lieut. Col. Mudge. But with these exceptions, no other elevations in the island were ascertained. A barometical measurement which I have made of nearly all the mountains and other remarkable places, has amongst other advantages, enabled me to give a vertical section of the chain throughout its whole extent, which agrees very well with a profile view of the island, taken by Murdoch McKenzie from the Mull of Galloway.

The spelling of the Manx names along with their pronunciation and signification has been furnished me by several persons in the isle, well versed in the knowledge of their native language, but I am particularly indebted for it to the Revds. H. Stowell, T. Howard, and Wm. Fitz-Simmons.

The length of the island is computed at upwards of thirty English miles, of which about five-sixths are occupied by a large body of mountains stretching from North-East to South-West; its breadth varies from fifteen to eight miles.

The chain spreads or swells out to the northward contracting itself to the southward into the Calf or *Barrow* of Man, which latter is rather less than six hundred acres in superficial extent, offering thus a gradual slope of fifteen hundred and forty feet from the top of Snei-feldt down to Burchet's house on the southern cliff of the Calf, that is to say, a depression of nearly a quarter of a mile in twenty-one miles taken in a straight direction, or, on a mean average, of about seventy-three feet per mile.

Estimating the mean breadth of the mountainous belt at four miles and a half, and its length at twenty-five, we should have for its superficial extent one hundred and twelve square miles and a half, which when referred to the whole area of the island, on the supposition of its being on a mean average, eleven miles and three quarters broad, by thirty miles long, or three hundred and fifty-two square miles and a half, would give one third, by approximation, for the ratio of the moory and uncultivated land to the land that is under tillage; there can be no doubt however, but a considerable proportion of the former is susceptible of being reclaimed.*

Parallel to each other, but at a distance respectively different, and *nearly vertical to the main direction of the chain*, there are three transverse vallies, the bottom of which, if not on a dead level with the sea, comes at least very near to it. The first of these is situated in the middle part of the chain, and the road leading from Douglass to Peel town passes through it. Its watershed is one hundred and twenty-six feet above the level of the sea, from which on the northern side rises a steep slope of 1352 feet to the top of the North-Greebah, and on the southern side a nearly vertical precipice of 609 feet to the top of the North Slieau-Aalyn above the hamlet of Mullin-y-Chlea, which stands 93 feet only above the sea.

The second transverse valley is about ten miles in a direct line to the south of the first, between Purl-Keill-Moirrey and Port Erin. Its watershed is 81 feet above the level of the sea, and is a low

* According to Mr. J. C. Curwen's calculations, the Isle of Man contains 245,760 Acres. viz.

100,400	of mountain
69,045	for grazing
30,158	in oats
15,079	under barley
14,761	under green crop, 710 of which may be considered as potatoes
9,047	in wheat
7,270	in roads, rivers, houses
Total 245,760	Acres

Report of the Agricultural Society in the Isle of Man.—Workington, 1810.

ridge of land, formed by the gradual slope of Slieau-y-Carnane and the high land of Spanish head.

Two miles farther to the south, the narrow channel of the Calf, about two furlongs in breadth, forms the last transverse valley. The small Isle of Kitterland lies in the middle of the Strait, connected by shelving rocks discernable only at low water, both with the main of the Isle of Man, and with the Calf itself.

It is a remarkable fact that the trifling elevation of these three sections decreases southwards, down to the last which is below the level of the sea.

A fourth flat, more considerable indeed than any already spoken of, may be said to exist on the outskirt of the chain northwards, occupying that fenny plain anciently called "The Curragh," and now transformed into one of the most fertile tracts of the whole island.*

The chain of mountains that forms the middle part of the Isle of Man, considered in itself, might perhaps with more propriety be denominated a *group* than a *chain.* It is a rising " en masse" of the land, a common broad basis or foundation on which rest several mountains otherwise unconnected with each other, though disposed in some regular order.

The narrow Glen of Mullin-y-Chlea, may serve to distinguish the mountainous group into two divisions, the one north, the other south. In the northern district of the group, two extensive lines of mountains and a central one, may be traced without difficulty. The

* Very large trees of oak and fir have been found buried in the peat of the Curragh, some two feet and half in diameter, and 40 feet long. The oaks and firs do not lie promiscuously, but where there is plenty of one sort, there are generally few or none of the other.——Wilson's History of the Isle of Man.

Mr. J. C. Curwen seems to think that the area of the flat country comprehended between Ramsay and Kirk-Michael, Jurby-point and Aire-point, may be rated at 40,000 acres, that is to say, according to his above referred to calculations, to a little less than 1-6th part of the whole area of the island.

Agricultural Report, p. 153.——Workington, 1810.

latter having Snei-feldt almost in the centre, comprehends the highest ground and the mountains of North Bor-roilva, Gob-y-Scioot, little and big Snei-feldt, Bein-y-phot, Kanaghyn and North-Greebah.

A boggy and elevated table-land lies on both sides of the central line of mountains, separating it from the two exterior ones. The summits of the extensive mountains do not all of them greatly surpass the elevation of the intervening table-land itself.

In the southern district of the group, the two exterior and skirting lines of mountains do not exist, but the eastern side of the mountains is rather scooped out and smoothed into a gentle and gradual declivity; whereas the western side constitutes a range of cliffs abrupt in most of its extent.

The steepness of the exterior mountains is nearly the same on each side. The northern boundary of the group terminates almost abruptly, and beyond the Curragh, lie the Balla-chyrrim hills, a low range formed of loose sand and gravel, facing the northern escarpment of the group, and then passing southwards in a parallel direction between the coast and the western exterior line of mountains.

A little to the north of the Balla-chyrrim hills, is a shingly beach, insensibly declining towards the sea, and formed of water-worn pebbles and sea-sand. The latter is hardened and binds the pebbles strongly together. It is the opinion of several persons in the isle, that the land in this quarter is gaining sensibly upon the sea. Some go so far as to say that the increase is not less than two yards in a year.

There are but few water-courses of any magnitude and extent in the Isle of Man. Sulby River the largest of all, irrigates the Curragh, and from the village of Sulby to Ramsey* where it

* Roms-waay-wide or roomy bay.

empties itself into the sea has but a very inconsiderable fall. From Crammag-bridge down to Sulby the stream runs at the rate of 452 feet within three miles; from thence higher up near to its source no computation of the kind can be made, as it is no longer one regular body of water but an assemblage of many little rivulets flowing down from the slopes of the mountains in every direction, particularly from the mountainous pasturage called *Mount-Pellier*.

The watershed of the elevated and boggy table-land that separates Mullach-Oure from the central line of mountains, gives rise to two other water courses, which from their common origin run in a contrary direction. The *Bright-river* after it has watered the Baldwin-valley empties itself into the sea at Douglass. The Laxey river flows through the valley of that name. Allowance being made for the windings of the Bright-river, it falls at the rate of 1395 feet within six miles, a fall rather considerable.

Both the Black-water and the Peel-river that issue from the watershed between Douglass and Peel-town are inconsiderable streams.

From the southern group of mountains come out two or three rivers, Glen-Moy, Cass-ny-Hawin and Castle-town rivers; the two latter flowing into the eastern part of the Irish Channel, and the first into the western.

The vale that is irrigated by the Moy river (Muigh a Druid) is extremely picturesque, the windings, which are short and frequent, expose unexpectedly to the traveller's eye, scattered cottages along the sides of the river. Cass-ny-Hawin and Castle-town rivers have a course much more open, owing to the character of the country which they traverse. Several other streams indent the coast of the island, which from the shortness of their course and the diminutive quantity of water they discharge into the sea, do not seem entitled to any farther notice.

I shall speak first of the *Compound Rocks*, and secondly of some *Simple Minerals*, as they occur *loose* or in *situ*, mentioning besides in each division under a particular head the primitive rocks, and those that belong either to the class of Transition, or to that of the Flœtz-Rocks.

I. *Compound Rocks in Situ.*

(*a*) *Primitive Rocks.*

† *Granite.*

Very little of the oldest member of the primitive class of Rocks is to be seen in the Isle of Man in *Situ*, nor is it the genuine old granite. Some doubts therefore may be entertained whether in the places where it occurs it does not lie in beds, rather than forming the universal foundation of the Isle.

Along the slope of Dun How, on the road from Laxey to Ramsay, and in the middle feeder of a stream that runs into the sea, occurs a small grained granite much decomposed, the quartz bearing but a very small proportion to that of the felspar: when breathed upon, the rock emits a strong argillaceous smell.

The same small granite, but in a sound state, is to be seen at Dun-bridge.

The spot where it comes to the surface may be three or four hundred feet above the level of the sea, but I have made no observation that enables me to determine accurately.

Another small grained granite was found in the working of a lead mine at Foxdale, a place situated nearly in the middle of the island, and 346 feet high.

If the information I received from an old English miner who had been employed the whole time the works were carried on be correct, they came to the primitive rock in sinking a shaft forty yards deep. There the granite was found to form the north side* of the vein, the galena adhering to it, while the south side was a stratified rock, which I shall hereafter mention. Whatever may be the depth at which the primitive rock was first remarked, there can be no doubt as to its existence, from the multiplicity of pieces of all sizes I found among the rubbish of the mine, and which were pointed out to me as such by the miner himself.

The rock is of a coarse grained texture, somewhat loosened, chiefly composed of quartz concretions, with reddish and decayed felspar along with some plates of white mica.

The mean specific gravity of the different sorts of granite above-mentioned, is 2, 81. From the granite above described, we come at once to the clay slate formation. The subsequent or intermediate members to granite in the series of the primitive rocks, viz. gneiss and mica slate, being either wanting absolutely, or if they exist at all, having escaped my attention, or being for the present concealed from our sight.

†† *Clay-Slate.*

The clay slate formation in the Isle of Man does not appear to belong to the oldest kind of Werner. It is almost limited to the high ground occupying Snei-feldt, Bein-y-phot, South Bor-roilva, and Cronk-ne-liry-Lhaa. It also occurs at Mount Pellier as hone stone; at Peel-hill and Balla-Gawn, as roofing slate; and as a reddish

* The miner from whom I received my information is a Yorkshire man, and used the technical word *cheek* instead of that of side; an expression which I understand is likewise employed amongst the Derbyshire miners.

half-decomposed slate along the mountainous road that runs from Ramsay to Douglass, between Slieau-Lhearn and little Snei-feldt.

The clay-slate of Snei-feldt has a close texture. Its basis is remarkably fine, the gloss not very resplendent: it fuses into a brownish enamel, and is traversed by slender veins of granular and whitish quartz.

The clay slate of Bein-y-phot has a dull black-brown colour, while that of Cronk-ne-liry-Lhaa is sometimes so glossy as to resemble plumbago, is soapy to the feel, fusible into a yellowish and bubbly enamel, the fracture is foliated, with some minute specks of white mica.

On the slope of South Bor-roilva the clay slate assumes a more flinty character, the grain is also very close. At Peel-hill, in a situation still lower than on the slope of South Bor-roilva, we come to another flinty clay slate, in the basis of which are distributed extremely minute specks of mica; it fuses into an olive brown enamel. The rock is quarried, but the beds that are used for roofing alternate with two others of a different nature. The one is a greyish compact felspar, the structure of which is rather thick slaty, with a close texture, the fracture is short scaly, it contains dispersed specks of mica, and fuses into a white frothy enamel. The strata run nearly East and West, dipping at an angle from 75° to 90°. The other bed alternating with the roof slate is called the *Knobby Side*, and forms the wall of the quarry itself. It has a silky lustre, and the planes of the strata, which are nearly vertical, instead of being even, offer little cavities smoothened and adapted for the reception of prominent parts similar in dimensions that exist on the contiguous bed. There is another roof slate at Balla-Gawn of a dark grey colour, rising by flags and of a fissile texture.

The clay slate of Mount Pellier has a structure rather thin slaty, it is ferruginous on the joints, but the colour of the basis is greenish grey, of a very fine grain, and full of cubic iron pyrites. It is a fact worth noticing, that the parts of the rock contiguous to the pyrites are whitish and earthy.

The last sort of clay slate mentioned as occurring between Slieau-y-Carnane and little Snei-feldt, has a violet reddish tinge. The structure is fine slaty, the texture more clayey; talcose linings impart to the spontaneous joints a glossy character. Its readier decomposition makes it a better support for vegetation. The mean specific gravity of the different sorts of clay slate enumerated here, is 2,757.

(*b*) *Transition Rocks.*

We pass from the clay slate formation to transition rocks through the most insensible gradations, and in this instance it is to be remarked, that it is the grey-wacke and not the limestone which forms the oldest member of the series.

Grey-Wacke.

In the Isle of Man this rock, as far as my observation has gone, never contains organic remains. It is farther to be observed that the tract of land occupied by the grey-wacke is less elevated generally speaking, than that appertaining to the clay slate. We can trace the grey-wacke all along the contour of the island, and, except those places where it slopes down gradually, and is outskirted by the flœtz-limestone receding into the sea, it forms a range of bold cliffs; at Maughold-head, Banks-how, Douglas'-head, Walberry-how, Spanish-head, the Calf of Man, Brada-head, Dauby-point, and in the intervening space between Peel-town and Kirk-michael.

Cronk-dhoo is the highest place where I have observed the grey-wacke. The shade indeed that seems to discriminate it from the clay-slate is so delicate, that were I to speak decidedly it would be rather unphilosophical. It has a grey colour inclining to a greenish hue, the joints ferruginous; it possesses a silky lustre which it seems to derive from talc intimately blended or interwoven with the basis itself, but there are besides a good many small specks of mica.

At Banks-how the grey-wacke has a much more decided character. It is rather thick slaty and of a granular texture, traversed by veins of white quartz standing out in relief. The basis has a greenish tinge approaching to grey, contains no spangles of mica and comes near to quartz sandstone. When disintegrated it forms but a meagre soil, fit for little else than oats.

Large tabular masses distinguish the grey-wacke of Clay-head. The fracture in the small is granular-scaly, the colour greenish grey, passing to ferruginous on the natural joints, it does not fuse unless where there are spangles of mica.

Near Laxey there is a grey-wacke-slate used as flags for flooring houses, it is scarcely fusible but for the mica there is in it, thin coatings of an ash-grey colour over-run the surface.

The following beds of grey-wacke-slate, alternating with each other, appear on the south quay of Douglass.

First variety. Texture earthy, of a dirty grey colour, contains spangles of mica, fuses into a whitish enamel.

Second variety. Striated, of an hard and dry aspect, infusible, or merely glazed from the mica that enters sparingly into its composition. The colour varies from greyish to olive-grey.

Third variety. Granular quartz forms the basis of it, in which are interspersed some small grains or nodules of transparent quartz, and some specks of white mica.

The *Fourth* and last variety, is a granular quartz over-run by veins of the same substance. There are in it but a few specks of mica.

The grey-wacke of St. Ann's-head is distinctly stratified, the planes of the strata being quite even, a mode of structure which originates from an accumulation of specks of mica, which render the rock readily fusible into a brown-greyish enamel, while it is infusible in those parts where the mica is wanting.

Along the shore between Kirk-michael and Peel-town, the grey-wacke is rather thick-slaty, traversed by slender and parallel veins of white quartz, coeval with the rock itself since they occur along the seams of stratification. The mean specific gravity of seven specimens of grey-wacke is 2.702.

C. Flœtz-Rocks.

† *Limestone.*

It would seem as if the appearance of the limestone was connected with the absence of the exterior line of mountains on the eastern side of the South Group. We trace it from Cass-ny-Hawin River to Purl-Keill-Moirrey (Langness-point excepted) but it never reaches to any elevation on the slope of the mountains; it is confined to the shore or its vicinity.

It lies conformably over the most superficial of the produced strata of grey-wacke, but the dip becomes less as the strata retreat farther back from the land into the sea. It may be comprehended between 10°. and 20°.

This secondary limestone is accompanied by the magnesian limestone, but I cannot say that the one overlies the other. They rather seem to occur by separate beds, or sometimes by patches, the one within the other. The magnesian limestone does not put on that regular stratified appearance which is so conspicuous in the other, nor have I observed in it any organic remains but in one single instance, and they are similar in their composition to the stone itself.

Mr. Parkinson has most obligingly furnished me with a list of the organic remains contained in the limestone of the Isle of Man, and he farther remarks, that the whole much resemble those found in Westmoreland, Cumberland, Durham, and, as far as he can judge, those of Kilkenny in Ireland.

The following are the organic bodies contained in the specimens that were submitted to his examination.

A large madrepore from two to three inches in diameter with distinct branches, a small madrepore with distinct branches, minute madrepores and entrochitæ, large trochitæ and terebratulæ, the latter varying from two inches to half an inch in diameter, large entrochi, small fragments of minute trochitæ.

The limestone of Castle-town, Scarlet, Pool-vash, and Ball-Fhallack is of a grey, or more generally of a dark grey colour: the texture compact with some lamellar concretions. It is traversed by slender veins of calcareous spar, and the *dip-joints** are coated

* This is an expression I beg leave to introduce, and refer to the judgment of Geologists. All the stratified rocks, but particularly those that have been deposited in a rather horizontal situation, are divided by rents perpendicular to their direction, corresponding therefore with their dip, into solids of dimensions more or less regular, and usually similar in the same individual strata. Thus if the structure of a rock be middle thick-slaty, it will divide itself spontaneously into *rectangular solids.* When

with crystallized calc spar. As the texture becomes more compact it gets harder and of a more intense colour, approaching to black; the fracture at the same time approaching to conchoidal. Iron pyrites dispersed through the mass is not uncommon, and when scratched the smell of sulphuretted hydrogen is rendered sensible: it burns very white, a circumstance which shows that the colouring matter, being volatile, is of an animal or vegetable origin. In diluted muriatic acid it makes a rapid and brisk effervescence, leaving rather a considerable residuum. The mean specific gravity, as resulting from eight specimens, I found 2,704.

I am not aware that the dark marble-limestone of Pool-vash contains organic remains; I have seen stripes or veins of lamellar and greyish limestone full of petrifactions alternating with the darker variety that remained quite freed from those exuviæ.

Thin and crumbling strata intervene between the solid strata of limestone. They are called *Soles* in the Isle of Man, but generally *Partings* among the miners.

The magnesian limestone in the places where it occurs, differs enough in itself to induce me to give a particular description of it. At Cass-ny-Haw'in it is either finely granular or in lamellar and well determined crystals. In the latter case it abounds with small cavities filled with crystallized rhomb spar, the crystals of which

the thickness of the strata bears a more equal proportion to the length or respective distance of the dip-joints, the natural divisions will come to a *cubical* form. If on the contrary, the structure be thin-slaty, the rocks will rise spontaneously under the form either of *flags* or *slates*. Whatever may be the shape of these natural blocks, their two contiguous sides are constantly coated with the predominating ingredient of the rock itself in its present state. Thus if the rock be quartzose, the coatings of the dip-joints will be veins of pure white quartz; if it be calcareous, the coatings will be crystallized calcareous spar, but unless we cause artificially the splitting of the rocks to take place, seeing but a vertical or a horizontal section of the coatings, we are apt to adopt the wrong opinion they are *veins* instead of *layers*.

turn quite brown before the blowpipe. The texture of the lamellar variety is not so close as that of the other. The specific variety of the latter is 2.777, and that of the first 2.820.

The magnesian limestone that appears along Castle-town river from Ball-Fhallack towards Athol-bridge, is remarkable for a circumstance that has not as far as I can remember been yet noticed. I mean the occurrence of quartz-nodules, sometimes above the size of a pea and even of a bean. The quartz is quite glassy, and the concretions perfectly distinct, as if they had been water-worn and subsequently imbedded in the limestone itself. This is not however a conclusion I should adopt, as it seems to me that their existence may be better accounted for by way of crystallization. The colour of this magnesian limestone varies from bluish-grey to dirty-yellow; it makes a very slow effervescence with diluted muriatic acid, contains rhomb spar either in lumps or on the seams of stratification, and sometimes sparry iron ore; the latter before the blowpipe assumes the character of a slag, which acts sensibly on the magnet, whereas the bitterspath, though it turns brown, is not attractable. The powder of the sparry iron ore of a brown colour effervesces briskly with diluted muriatic acid. The specific gravity from three specimens is 2.81.

At Scarlet point the magnesian limestone has a yellowish-grey colour, and is close in its texture. Patches of compact greyish lime-stone are imbedded in it.

A dyke occurs in the limestone formation at Scarlet point, upon which I shall say no more for the present, as it is a subject which I intend at some future period to bring before the attention of the Society.

In the little bay of Purl-Keill-Moirrey, the limestone on account of its low retreating strata, imitates a sort of causeway, ending towards the high land of Spanish head.

†† *Amygdaloid.*

Kaal-Farane and Cromwell' walk, two places that separate Scarlet point from the entrance of Pool-vash bay, present an unstratified bed of amygdaloid that overlies the limestone itself.

The basis of the amygdaloid is a wacke of an earthy texture, dull and of a greenish-grey colour, emitting a strong argillaceous smell when breathed upon. There are in the powder a few particles that effervesce with acids; the rock however fuses readily into a dark olive bead that is attracted by the magnet. There are in the basis nodules of lamellar calcareous spar, lined on their periphery with iron pyrites: the cavities they are imbedded in are smooth. When by the action of external agents the more tender nodules have been washed away, the rock partakes of the appearance of a slag, inasmuch as the basis is itself of a dirty red brown colour. The mean specific gravity from three specimens is 2.592.

††† *Sandstone.*

It occurs both under the form of fine granular and of conglomerate, of a red and grey-white colour, a little to the north of Peel town on the shore, and also on Langness isthmus. In the first place the strata run south-west and north-east, dipping north-west at 39°. At Langness, as we approach towards the south point of the isthmus, the conglomerate strata get higher and more thick-slaty. The materials entering into its composition are of a large size and much loosened. Along the Castle-town River, the sandstone overlies the limestone.

II. *Compound Rocks not in Situ.*

(*a*) *Primitive Rocks.*

Granite.

I am aware but of two modes of explaining the existence of loose blocks of rocks that are spread over the face of a country, whatever may be the nature of the blocks themselves, either to suppose they are *extraneous* to the places where they now lie, or that, howsoever unconnected they may appear to be with the materials that surround them, they are nevertheless in their *birth-place*, and have been disintegrated in *situ*, covering and resting upon solid and continuous strata *similar* to themselves.

The only criterion perhaps applicable to the determination of this important question is the following. When by farther investigations we have found that the hidden and continuous rocks are similar to the blocks themselves, we may safely venture to say that the latter are *indigenous*.

I am inclined to think that several of the loose blocks I am going to describe, whenever they occur in *any number*, are in their *birth-places*.

On the beach towards Aire-point there are innumerable loose blocks of granite, one of which, rather large in its dimensions, I observed on Aire head at the elevation of 271 feet. They all in their characters differ but little the one from the other. The rock is a small-grained granite, composed of white felspar, quartz and black mica, with a few incidental plates of the latter that are white. In one of the specimens I collected, there is a rectangular piece one inch in length by half an inch broad, of very minutely grained granite with a predominance of mica.

On the slope both of South Bor-roilva and Cronk-ne-liry-Lhaa, in the southern part of the group of mountains, occur abundant blocks of rather decayed granite, composed of yellowish and white felspar turning to a state of earth, and disseminated plates of white mica. The texture is loosened to such a degree that large fragments often yield under the pressure of the hand.

I traced blocks of the same granite in Glen-Moy, though the bed of the stream is hollowed out in the grey-wacke formation.

The central stone of a Druidical barrow* in Kirk Ballaugh, is a small grained granite of white felspar, quartz, mica, and a great deal of hornblende.

†† *Mica-Slate.*

A vast number of blocks of mica-slate exist on the slope of Slieau-y-Carnane, another hill in the southern district of the group. The quartz is finely granular, and has a silky lustre, which it probably derives from a superficial covering of talc. The plates of mica are white and sparingly dispersed, sometimes crystallized.

I met at the village of Craig-neash with a large settled block of mica-slate. The quartz is of a dirty-grey colour. The plates of mica very few and falling into decay.

††† *Porphyry.*

Very numerous blocks of this rock occur on the beach at Aire-point. The basis is compact felspar of a flesh-red colour, turning

* All the *Runic* or *Danish* monuments so frequent in the Isle of Man, are (as far as my observation has gone) of greywacke, without one single exception. The inscriptions they bear are said to be written in the old Norwegian language: they are placed on the edges of the stones, whereas the carvings are on their flat surfaces. The latter appeared to me to bear some resemblance to the form of a snake.

yellowish and earthy when going to decay. There is some hornblende disseminated throughout the mass: a few crystals of lamellar and transparent felspar are also imbedded in the basis. The rock acts strongly on the magnet. It emits when breathed upon a sensible argillaceous smell.

†††† *Sienite.*

I noticed but one block forming part of the Druidical barrow already spoken of. The texture is unusually close. The two ingredients are crystallized and intimately blended together. The felspar fuses, but not readily, into a transparent enamel which is not frothy. There are besides in the mass some very minute crystals, of an yellowish colour with a vitreous lustre. (Qu. garnets?) Specific gravity 2.932.

††††† *Quartz.*

Several blocks of white and greasy quartz, some of which contain yellowish talc, form one of the circles of the Druidical barrow in Kirk Ballaugh. Sp. gr. 2.536.

†††††† *Garnet Rock.*

This rock, of an unusual occurrence I believe, I found under the form of water-worn pebbles on the shore at Kirk-michael, and as this is no place for vessels to lie at anchor, I have no reason to think they could have been taken as ballast and thrown away where I remarked them. The rock is highly magnetic, very hard and tough. The mean specific gravity 2.967, the extremes being 3.085 and 2.846. The mass is of a liver-brown colour, with many crystals of an orange or reddish-brown cast imbedded in it. Their fracture is vitreous, but sometimes displays a sort of lamellar texture. The crystallized garnets are much less fusible than the basis or massive garnet: the latter passes into a brownish bead. There are besides in one of the specimens some nodules of radiated zeolite or mesotype. In another the mass of garnet is blended with white felspar.

At B. Wodden I noticed a large block of granular quartz with garnets? and hornblende. The rock has a greenish-grey colour. The fracture in the small is granular scaly. Another rock, related to the preceding, is amongst the Druidical stones of Kirk Ballaugh.

(*b*) *Transition-rocks not in Situ.*

† *Greywacke.*

Between Ramsay and Aire-Point I saw in some heaps of stones a number of pieces and blocks of greywacke, passing from large grained into a small grained texture. The basis is greyish, the imbedded fragments are mostly nodules of white quartz with scraps of a dull and black sort of slate, fusible into a whitish enamel, and abraded plates or broad spangles of mica. The cavities that receive the nodules of quartz when freed from them, appear smooth and even. The pieces of slate turn sometimes clayey, micaceous, and of a brown ferruginous colour.

(*c*) *Flœtz-Rocks.*

† *Limestone.*

I shall merely speak here of some water-worn limestone pebbles found in great plenty from Kirk-michael to Jurby point, though no solid strata of this kind can be seen in *situ*. They are picked up and burnt for lime, which I was informed is preferred by the northern farmers to the Castletown lime for manuring the land. The colour of these pebbles is smoke-grey, the texture granular with lamellar crystals; they are soluble with a brisk effervescence in acids, leaving behind only an inconsiderable residuum. They contain organic remains.

III. *Simple Minerals in Situ.*

† *Lead Glance or Galena.*

Lead glance or galena is the most conspicuous of all the simple minerals I have to mention here. It forms three limited repositories, one at Laxey, the other at Foxdale, and the other at Brada head.

No workings are carried on at present.

As to the precise time those mines were first opened there is, I think, some uncertainty. It would appear from the following passage taken from Bishop Wilson's History of the Isle of Man, that there had been mines wrought at an early period; "Mines of "coal there are none, though several attempts have been made to "find them. But of lead, copper, and iron, there are several, and "some of them have been wrought to good advantage, particularly "the lead; of which many hundred tons have of late been smelted, "and exported. As for the copper and iron-ores, they are certainly "better than at present they are thought to be; having been often "tried and approved of by men skilled in those matters. How- "ever, through the ignorance of the undertakers or by the un-

" faithfulness of the workmen, or some other cause, no great mat-
" ter has as yet been made of them." *

These three repositories of lead lie in a grey-wacke formation, with the exception before mentioned, when speaking of a small grained granite found in the sinking of a shaft at Foxdale.

From the direction of the metallic veins, they seem to intersect at a greater or lesser angle the greywacke-strata. The direction of the metallic vein at Laxey is West South West, and East North East; at Brada head, the shafts have been opened in a line that keeps nearly the same direction.

The inclination of the metallic vein with respect to the horizon, both at Laxey and Foxdale, is two yards in six.

* Page 449. Vol. I.

Since the above was written, a letter which I received from Mr. William Geneste of Douglass, answering some inquiries I made, contains the following more precise information on this subject.

" Mr. Fitz-Simmons, who is preparing to publish an extensive work on the ancient History of the Isle of Man, states, that mention is made of the mines of the Isle, in the time of Sir Stanley * 1st and 2d. Those at Brada, he believes, were first wrought; whether those at Foxdale were then opened may be doubted; those at Laxey were opened and wrought by a mining company of Cumberland, about the commencement of the last century."

" Mr. William Scott of Douglass conjectures, that the mines at Brada were wrought previous to the discovery of gunpowder, from *Feather-wedges* (a contrivance for breaking asunder rocks, which is now performed by gunpowder) having been found in those mines."

Mr. William Geneste informs me farther, that he lately found in some books (titled Charge of the Revenue) in the Duke's office, in Douglass (called the Seneschal's office) " that the last Earl of Derby had the mines wrought, paying the workmen at the rate of £3 manx ‡ per ton, for the ore (lead) raised. In the year 1709, he paid the miners for about 70 tons; from the year 1709 to 1713, about 30 tons yearly. A new smelting house was built in the year 1711. The working of the mines was totally suspended about three years ago."

* The first Sir Stanley appointed King of Man, was by grant from King Henry 4th, in the year 1407.

‡ The manx money is to the British in the proportion of seven to six.

The breadth of the main metallic vein at Foxdale, the *partings* being included, was computed to be full six yards.

In all the three places the vein appears adherent to the contiguous rock, whether it be greywacke or small grained granite.

At Foxdale a cross metallic vein of lead also was found running a few points from the North and South, that is to say, intersecting the main vein at a great angle; at the junction or *counter*, the ore grew richer, and many *knockings*, *shods*, or balls occurred. The cross course was as fertile as the main vein itself, if the information I received be correct. Its inclination likewise, with respect to the horizon, was fully as considerable.

According to Mr. Wood's statement, it would appear that the ore at Brada-head was chiefly sulphuret of copper. *

I shall now enter into a more minute examination of the several substances which accompany the lead-ore at those three places.

Laxey-Mine.

The galena of Laxey, when pure, is possessed of the lustre characteristic of common lead-ore. Its specific gravity is 7.652. †

Sex octogonal carbonat of lead, along with efflorescent and fibrous carbonat of copper, are the various minerals attending the lead-ore. A button of copper may be easily obtained by exposing the carbonat of copper with borax to the heat of the blowpipe.

The vein-stone or *Rider*, is a greywacke breccia, composed of pieces of silky-greywacke, quartz, and bitterspath, with much brown blende.

* An Account of the Isle of Man, by George Woods, London, 1811.

† The Bishop of Landaff states the produce in silver on some Manks ore, to have amounted to 20 ounces in a ton of lead. By some of the workmen it is asserted that the quantity of silver has occasionally amounted to 35 ounces in the ton.
Watson's Chem. Essays, Vol. 3. p. 328. 7th Edit.

The walls of the vein are formed of silky greywacke with pieces of bitterspath, and a few flesh-red and lamellar crystals of calc spar.

Foxdale Mines.

The specific gravity of a rather impure specimen of lead-ore, I found 6.095.

Amongst the stony substances that fill up the vein, I remarked the following varieties.

A semitransparent and bluish calcedony passing to white; it is zoned, but the zones are not apparent without the assistance of a magnifying glass; common galena and some iron pyrites are disseminated throughout the mass.

Sometimes the calcedony verges into white quartz, blended with sparry iron-ore scarcely effervescent with nitric acid, turning almost black before the blowpipe and acting very powerfully on the magnet. It is likewise accompanied by iron-pyrites.

The sparry iron-ore in larger lamellar crystals appears of a dark colour, and contains so much of iron as to act by itself on the magnet. Galena adheres to it.

The greywacke that forms the South side or *cheek* of the vein, is of a greyish colour with a silky lustre; the common lead-ore adheres to it. In a granular and drusy quartz filling up the vein, I noticed a few garnets.

Brada-head Mines.

The specific gravity of a less impure specimen of lead-ore than that of Foxdale, was 6,622.

The principal vein-stone through which the ore is disseminated, is a yellowish granular quartz that includes iron pyrites.

†† *Dun Earth.*

On the part of Dun How where the granite appears at the surface, and in a natural excavation, but which I believe has been enlarged by art, there is a brown sort of powder, said to be used by the inhabitants for the cleaning of plate.* It feels rather soft to the touch; does not effervese with acids; fuses *per se*, but not readily, into a greyish enamel.

††† *Marl.*

All over the curragh, and on the beach also at Kirk-michael, a substratum of marl several feet deep, underlies a light and sandy soil.

B.-Vodden marl.

Calcareous marl of a light flesh colour, soft enough to be cut with a spade, feels almost greasy to the touch, basis extremely fine, texture dull and earthy; no other discernible particles in the mass but very small spangles of white mica; adheres to the tongue strongly, is soluble with a brisk effervescence in diluted muriatic acid, leaving a considerable residue readily fusible into a slightly magnetic olive enamel.

Kirk-Michael-beach.

Calcareous marl of a grey-reddish colour, not so soft as the preceding, owing to some sandy particles immersed in the basis; leaves in diluted muriatic acid a more abundant residue, not so easily fusible; the enamel of an olive-green colour.

There is another variety of calcareous marl in the same place of an ash-grey or of a dun colour.

* Mr. Wood's account of the Isle of Man.

The farmers in the northern part of the isle make use of the above marls, particularly of that from B. Wodden to manure their land. According to their expressions, marling *strengthens* the land, whereas lime *purges it*, two different ways of obtaining the same end, the one by adding what is supposed to be wanting to the land to make it good, the other by getting rid of what is reckoned to be hurtful to it. Marling once in twenty years, is considered as sufficient to keep the land in good order under a proper course of crops: eight or nine of which may be taken successively immediately after the operation.*

One hundred and fifty tons of marl are computed to be necessary for an acre of land. The expences, supposing the carriage not to exceed a mile, will amount to six pounds sterling. The cost of liming, a practice chiefly used in the southern part of the isle, is nearly the same. Ninety bushels of lime is the quantity allowed for covering an acre of land.† Sea weeds previously made into a compost, are also much used in the south district of the island. The marl by lying at the surface sometimes becomes considerably lighter. When dung mixed with hot lime is put upon a marled ground, the fermentation that ensues produces a very surprizing effect.

†††† *Coals.*

It is unfortunately more as a warning against the delusive accounts that have circulated abroad with respect to the discovery of

* Mr. Curwen's Agr. Report, p. 153.

† In Mr. Thomas Quayle's "General View of the Agriculture of the Isle of Man," it is said that from 1807 to 1811, 84,992 barrels of lime have been sold from the several kilns fitted up for that purpose in the south-eastern part of the island.

coals in the Isle of Man, that the present topic is introduced here, than to prove their real existence. To preclude however, farther investigations and observations on the score that coals cannot possibly be discovered, would be presumptuous and imprudent, but nobody has yet, that I am aware of, substantiated their existence. The only serious attempt I believe to find coals in the isle, was made at Derby-haven, many years ago by a speculator from Cumberland.* After having gone to a certain depth, not finding traces of them, he gave up the search as fruitless.

While I was in the isle (June 1811), two or three spots in the north-western part, were particularly pointed out to me as places where coals did *actually* appear, or were *cropping out.* But when the matter was strictly enquired, the reports turned out unfounded.† While on the subject of coals, I shall beg leave to present here an account of the coals imported into the Isle of Man from Whitehaven in the county of Cumberland, arranged under the form of two series; the one comprehending ten years from 1781 to 1790, the other including twelve years from 1798 down to 1809. Both statements may be relied on, the first was inserted in a scarce book,‡ the second in a late and though local, most respectable publication often already referred to.§

The increased consumption of coals in the Isle of Man will not

* Mr. Curwen's Agr. Report, p. 112.

† During the whole of my excursion through the isle of Man, I had the pleasure of being accompanied by Mr. Thomas Scott, brother to the much celebrated Scotch Poet of that name. Mr. Wm. Geneste, a well informed gentleman, and a native of the isle, joined our party while we were examining the southern part of the isle. From the two above mentioned gentlemen, and generally from all those to whom I was introduced in that island, I received the most ready and kind attentions as well as much information.

‡ The Report of the Commissioners of Inquiry for the Isle of Man, 1792.

§ Mr. Curwen's Report of the Agricultural Society.

so much show an increase of population* as an increase of comforts amongst the inhabitants at large, the consequence of a more extensive system of cultivation, and the diminishing number of fishing boats that used to take out in the months of harvest upwards of 2000 of the most active inhabitants of the labouring class.†

An account of the coals imported into the Isle of Man for ten years, ending the 5th January 1791.

Years.	Chaldrons.‡	Bushels.
1781	2728	18
1782	2652	27
1783	2853	18
1784	3236	9
1785	3585	
1786	3796	18
1787	3379	18
1788	3719	27
1789	3659	18
1790	4321	9
	Total 33932	18

An account of the coals imported into the Isle of Man within twelve years; viz. from the 5th January 1798, *to the 5th July* 1810.

Years.	Chaldrons.	Bushels.
1798	5559	18
1799	5258	9
1800	5693	27
1801	6130	0
1802	6379	27
1803	7041	16
1804	7244	27
1805	6823	22
1806	6937	35
1807	7461	25
1808	8807	4
1809	9020	4
	Total 82357	34

As to the great advantage the inhabitants would derive, were coals to be discovered on their isle, I should entertain some doubt, when I consider that the inhabitants of the city of Dublin have their coals put into their cellars at less expence than the persons who live in the County of Cumberland, twelve miles distant from

* The Census of 1792, returned 28,000 inhabitants nearly, but Mr. Curwen observes that all the estimates of the population of the Isle of Man published at different periods, have been much overated. He hardly thinks it can exceed 23,000 or even so much, viz. 6000 inhabitants at Douglass, 2000 at Castle-town, 2000 at Peel, and 1500 at Ramsay, besides 11,000 spread over the island, considering how few villages there are, and how small their sizes are.

† Ibid.

‡ A chaldron is a measure of 36 bushels.

the coal-pits of Whitehaven. In the present state of affairs in the Isle of Man, any thing, I should apprehend, that would have a tendency to diminish the number of hands that may be employed in extending the culture of the land, would rather operate as a check on the farther improvement of the island itself.

IV. *Simple Minerals not in Situ.*

It is very doubtful whether the minerals mentioned here, do really belong to the Isle of Man. They made part of a collection that was in the possession of the late Lord Henry Murray, and were obligingly communicated to me by Mr. Wm. Scott, the Collector of the Custom-house at Douglass. Many of them had no labels affixed to them. The informations I received concerning them, I shall here communicate.

Wolfram, either in detached pieces or fragments, or adherent to quartz: supposed to have been found in loose pieces at the surface of the ground, on the slope of South Bor-roilva, two miles from the mines of Foxdale.

Tin-Stone. Great doubts may be entertained as to its occurrence in the Isle of Man.

Earthy talc. Said to have been found on Mount Murray.

Could we depend on the locality of the earthy talc here, its occurrence would rather favour the possibility of that of tin, as the two substances often accompany each other.*

I consider myself warranted to deduce the two following conclusions.

1. That it appears extremely probable that at some period or

* Jameson's Mineralogy. Vol. 1. p. 431.

other, a subsidence to the south of the whole chain "en masse" took place, which caused the three dislocations referred to in the course of this paper, and which are nearly at right angles with the direction of the chain itself.*

2. That the same subsidence may be supposed to have produced the general dip of the stratified rocks to the southwards.

* At Spanish head, on the spot called *Kione-Gogan*, (a head resembling a noggin) the strata have been rent asunder in two contrary directions. The contiguous sides being now several yards distant the one from the other. The principal rent runs north and south, the transverse one east and west, presenting an assemblage of four large square compartments.

Is this referable to the great subsiding pointed out above? or more likely, to the cause that gave origin to the metallic veins, and particularly to the cross course at Foxdale?

The grey-wacke slate of Spanish head splits naturally into long beams 12 or 15 feet long, fit for mantle-trees, and strong enough to bear the weight of the highest stack of chimnies.——Wilson's History of the Isle of Man.

Temperature of several Springs in the Isle of Man, to deduce by approximation the mean temperature of the climate of that island.

Names.	*Elevations in feet above the level of the Sea.*	*Temperature of the Springs.*
Farane-y-phing; pronounced Faraan-e-fing	1264 feet	45° $\frac{1}{3}$ Fahr.
On S. Bor-roilva slope	undetermined . .	45° $\frac{1}{2}$
Near to the top of Slieau-y-Carnane	960 by approximation	46°
Cass-ny-hawin, Head of the river	422	46°
St. Patrick's well; Kirk Lonan .	undetermined . .	47° $\frac{1}{2}$
Spring between Glen-Roy and Glen-Laxey	undetermined . .	47° $\frac{1}{2}$
South-Quay Douglass	0	48° $\frac{1}{4}$
Ditto	0	48° $\frac{1}{4}$
Pigeon-Spring, on Walberry How	undetermined . .	48° $\frac{1}{2}$
Hampton-house	407	49°
Ditto	ditto	49°
Vinch's well, Douglass-bay . .	0	49° $\frac{3}{4}$
Kirk St. Ann' Glebe	235	50°
Hamilton-bridge	220	50°
Fleshick bay	0	50° $\frac{1}{4}$
Kirk Lonan's Glebe	365	50° $\frac{1}{3}$
Burchet's well; Calf of Man . .	undetermined . .	50° $\frac{1}{2}$
Cregga well	uudetermined . .	50° $\frac{1}{2}$
Calf spring	0	51°
Mill-town spring	undetermined . .	51° $\frac{1}{4}$
South-quay, Douglass	0	51° $\frac{1}{2}$
Langness spring	0	51° $\frac{1}{2}$
Ball-Fhallack spring, pronounced Balla-Salley, the royal residence	undetermined . .	51° $\frac{1}{2}$
South-quay Douglass	0	52°
Balla cregga' How	undetermined . .	52°
Douglass-bridge, on the road to Castletown	0	52° $\frac{1}{4}$
Flax-mill Spring	undetermined . .	52° $\frac{1}{2}$
Fyshtel	0	52° $\frac{1}{2}$
Purl-Keill-Moirrey, Port-le-Murray	0	52° $\frac{2}{3}$
Mr. Gurley's well; Calf of Man .	206	53°
Kirk-Oncan . . . . , .	204	54° 0
		Mean 49.99

If we rate at 50° Fahr. the mean annual heat in the Isle of Man, we shall have it differing from that of London merely by 1° for a difference of 2°,41′ of north latitude. Comparing the same annual heat of the Isle of Man with that of Edinburgh, we shall find it surpassing the latter by 2°, 2′ Fahr. though the latitude of the Isle of Man be only 1°,45′ more to the south than that of Edinburgh.

The mean temperature of the month of June, 1811, in the Isle of Man, deduced from 128 thermometrical observations, I found to be 55°.81′ Fahr. but as most of the observations were made on the tops of mountains, the mean must be lower than it would have been had the observations been made in the plain. Thus I find that thirty-nine thermometrical observations (out of the series of 128) made by the sea side give for the mean 57°.37′, which when compared to the mean of 22 thermometrical observations made at the apartments of the Royal Society on correponding days, is deficient by 4°.35′. The London mean being 61°.72′, and that of the Isle of Man 57°.37′. At Belfast the mean is 64°.90′ Fahr. The mean height of the barometer for the same month of June, 1811, is as follows.

London - -	30.13295
Isle of Man -	30.11895

The frosts are short in the Isle of Man, and the snow does not lie long on the ground, especially near to the sea. I was informed by the Rev. Mr. William Fitz Simmons, that on the top of Snei-feldt it does not remain longer than two or three weeks, from Christmas generally, to the second or third week of January.

. . . . . .

Mountains and other Places in the Isle of Man, together with their heights, determined by the Barometer:* the whole arranged alphabetically, with References to the Numbers in the Map.

Name and Situation.	*Signification.*	*Number in the Map.*	*Elevation in feet above the level of the Sea.*
Aire-head	. . . .	1	271
Aire-how	. . . .	2	188$\frac{1}{2}$
Aire-brow (sea-mark) . .	. . . .	. . .	106
Athol Bridge	. . . .	45	143$\frac{1}{2}$
Baldwin Valley head . . .	. . . .	. . .	1395
Balla-cragga how	Rocky farm	44	412
Balla-chirrym; about the middle of the range . .	Dry farm	. . .	177$\frac{1}{2}$
Balla-gawn; about $\frac{3}{4}$ of a mile south of Kirk-Michael . .			
Balla-stowell	Stowell's farm . . .	11	500
Balla-wodden; about $\frac{1}{2}$ mile south of Kirk-Andrew			
Banks-how	. . . .	25	392$\frac{1}{2}$
Beary mountain	*Beiree*, tops of hills? .	27	900
Bein-y-phot	The Pot mountain . .	20	1750
Bool-benney; highest ridge on the road from Castletown to Douglass, between the 6th and 7th mile-stone . .	a place where furze grows	39	538
Bor-roilva, Baroil, Barroole, or Bourrul; North	Wild mountain . . .	12	1850†
.... South	. . . .	36	1545
Brada-head; high point . .	. . . .	47	767
.... low point . .	. . . .	46	412
Burchets' Hermitage; highest spot in the Calf of Man .	. . . .	49	461
Cairn	. . . .	24	1430
Calf of Man; Mr. Gurley's house	. . . .	. . .	206

* For the calculation of these heights I have made use of Professor Leslie's Sliding Scale.

† In the trigonometrical Survey, North-Berule, 1804 feet.

Name and Situation.	*Signification.*	*Number in the Map.*	*Elevation in feet above the level of the Sea.*
Caran-hill	Crown of the head . .	10	984
Carden	. . . .	26	1535
Carrick-hill	Rock-hill	6	627
Cass-ny-hawin; taken at the head of the river	The foot of the river .	. . .	422
Clarke's-hill	. . . .	7	889
Clay-head is the hill that lies N.E. of Banks how			
Cloven-stone; a Druidical monument, 1½ mile from Laxey, on the Douglass road			
Corrin's tower; highest point of Peel-hill	. . . .	34	675
Crammag-bridge on Sulby river	. . . .	. . .	452
Cregneish or Craig-neash .	*Neash*, rock . . .	. . .	520
Cronk-dhoo	Black hill	13	705
Cronk-ne-liry-Lhaa, or Cronk-ny-irrea-Laa . . .	Break of day hill . .	37	1445
Watershed, between Cronk-ne-liry-Lhaa and S. Borroilva on the road from Castletown to Peeltown .	. . . .	. . .	982½
Six mile-stone between Castletown and Peeltown; lower limit of the Turbary in that part of the island . . .	. . . .	. . .	692
Cronk-Ouyr, or Cronk Owre	*Ouyr* dun colour . . *Owre*, brown	3	186
Cronk-Shamrock, or Primrose hill	hill of tents	5	273½
Douglass-head	. . . .	42	315
Douglass-how	. . . .	41	466
Dun-how	. . . .	15	757
Dun-bridge; at the foot of Dun-how			
Foxdale or Foxtal mines, central part	. . . .	32	346
Glen-roy; at the Rev. W. Fitz Simmons' house; one of the highest habitations in the island	. . . .	. . .	493

Name and Situation.	*Signification.*	*Number in the Map.*	*Elevation in feet above the level of the Sea.*
Gob-y-Scioot, or Ghub-y-Scioot	*Ghub* is point; Water-spouts are called *Ghub-ny-spouts?*	22	1820
Gob-y-vullea, Gub-y-vulley or vollee	*Gob*, a beak *vully*, a height *vollee*, eye-brow . .	8	747½
Greebah or Greebey, North	*Grie*, grey	28	1478
.... South	. . . .	29	1355
Hampton House; about 2½ miles from Douglass, on the Castletown road	. . . .	. . .	407
Hamilton bridge	. . . .	. . .	220
Jurby point	. . . .	. . .	117
Karraghyn, or Karaghan .	. . . .	31	1520
Kennish's Hill	. . . .	4	508
Kione Gogan; the hill N.W. of Spanish head	. . . .	. . .	
Kirk Onchan	. . . .	. . .	204
Kirk Lonan; Kirk Leonard in the map	. . . .	. . .	365
Kirk St. Anne; Kirk St. Agnes in the map	. . . .	. . .	235
Laxey mines	. . . .	. . .	124
Laxey-valley-head	*Lax-waay* or *waag* Salmon-bay	. .	1264
Maughold Head	. . . .	14	475
Middle hill, about 1½ mile from Douglass, on the Castletown road . . .	. . . .	. . .	282
Mount Murray: the hill between K. Braddan and K. Marrown	Black hill	. . .	742½
Mount Pellier	. . . .	19	
Mullach Oure; Southern part of	. . . .	23	1540
.... Northern part of and lower limit of the Turbary	. . . .	23	1378
Mullin-y-chlea	The concealed mill .		
Mullin-y-chleigh	the mill on the Boundaries	. .	93
Mullin-e-Cleii	the playing mill . .		

Name and Situation.	*Signification.*	*Number in the Map.*	*Elevation in feet above the level of the Sea.*
Peel-Hill, high point . . .	. . . .	34	675
.... low point . . .	. . . .	33	330
Sartyl	. . . .	30	1560
Slieau-Aalyn, or Slieau-Chaillin	*Aalyn*, beautiful The Witches mountain		
.... North . .	. . . .	35	702½
.... South . .	. . . .	35	977½
Slieau-Chiarn	the Lord's mountain .	9	1068
Slieau-dhoo	the black mountain .	18	1215
Slieau-Lhearn	the broad mountain .	21	1533
Slieau-y-Carnane, or Slieau-y-Carnaane	. . . .	38	990
Head of Land, or overhanging cliff between Slieau-y-Carnane and Cronk-ne-Liry-Lhaa	. . . .	. . .	877½
Snei-feldt, Snioghtey, or Snawble; great . . .	Snow-field	16	2010 / 1990 } mean 2000*
.... little	. . . .	17	1775
Boggy Table-land, N.W. of Sneifeldt	. . . .	. . .	1154
Upper limit of the arable land, between Little Snei-feldt and Slieau-Lhearn . . .	. . . .	. . .	937½
Spanish-head	. . . .	48	550
St. Anne's head; low point .	. . . .	43	126½
St. John's chapel; the Tinnwald †	. . . .	. . .	130
Walberry How	. . . .	40	485
Watershed between Peeltown and Douglass	. . . .	. . .	126½
Watershed between Purl-keil-Moirrey and Port-Erin . .	The harbour of St. Mary's church, Irish Port .	. . .	81½

* Snea-fell, from the trigonometrical Survey, 2004
Snâfield, from Bishop Wilson . . 1740

† *Tinnwald* from the Danish word *Ting*, a court of justice, and *wald*, fenced. It is held on an artificial mount, near the middle of the island, in the open air.

III. *On the Granite Tors of Cornwall.*

By J. MacCulloch, M.D. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich.

I Have the honor of presenting to the Society three drawings which I have selected from my portfolio, for the purpose of illustrating the changes which the influence of time and weather produces on certain varieties of granite. The subjects are all chosen among the granites of the west of England; and that I might at the same time preserve memorials of circumstances which are remarkable independently of their geological interest, I have taken two of my examples from places which have called forth more admiration from the common spectator than even from the philosopher, and which form two points of attraction for the curious or idle who annually visit Cornwall. Not only indeed have idle curiosity and ignorant speculation busied themselves in accounting for phenomena which many of the vulgar have deemed little less than miraculous, but learned antiquaries have tortured their inventions and have constructed religious systems for the purpose of explaining these very simple and intelligible natural appearances, by the rites of a mysterious and Druidical worship. I trust I shall be pardoned, if while I deduce from these facts the geological consequences which depend on them, I likewise give a more particular detail of the appearances themselves which have excited so much of the attention of all visitors.

The Logging rock (Pl. III.) is situated on a peninsula of granite, in the parish of St. Levin, which stretches out about 200 yards into the sea, its isthmus still exhibiting remains of the ancient fortification of Castle Trereen. The mass of granite which forms this peninsula is split both perpendicularly and horizontally by numerous fissures, and is thus divided into a number of cubical and prismatic masses. A similar disposition in all the rocks of this shore has caused them to assume those singular forms which are so conspicuous at the Land's End. The appearance of the perpendicular fissures on approaching the Logging rock from the isthmus is so remarkable, that we might for a moment fancy it the effect of stratification, as geologists have in other instances been tempted to suppose. Crystals of tourmaline are found in this granite, which has supplied the cabinets of collectors with so many specimens as to be too well known to need description.

The general height of the mass of rock on which the logging stone is placed varies from 50 or 80 to 100 feet, and it exhibits almost all round a perpendicular face to the sea. It is divided into four summits, on one of which, near the centre of the promontory, the stone in question lies. If the whole peninsula be viewed laterally, the conformity of the rocking stone to the mass on which it stands and to the other small stones which crown the summits, is such that the eye cannot detect it, so perfectly it seems in its place. It is in the front view only that it appears detached, as if occupying an accidental and not its natural and original place. Its general figure is irregularly prismatic, and foursided, having at its lower part that protuberance on which it is poised. So inclined is the plane on which it rests, that it appears at first sight as if a slight alteration of its position would cause it to slide along the plane into the sea, standing as it does within two or three feet of the edge of the precipice. The breadth of the apparent contact between the plane and the centre of motion of the stone is about a foot and a half. As this support is curved only in one direction, being of a cylindrical and not of a spheroidal figure, the motion of the stone is consequently limited to a vibration in one direction, which is nearly at right angles to its longest dimensions. The general aspect of the stone would scarcely enable a cursory spectator to assign the reason of its vibratory power, as from the point of view in which it is usually seen, the centre of gravity would appear placed rather above than below the centre of suspension. It is said that the motion is now much more limited than it has been within the memory of those who live near it; a circumstance rendered very probable by the progress of disintegration at those points of contact where water can be detained. A continuance indeed of the very process to which it owes this property, must ultimately destroy its motion if it operates by bringing a wider surface into contact, thus defeating the enlarged vibration which would otherwise follow from the increasing distance between its centres of suspension and of gravity. A quantity of loose quartz gravel may be generally found near the points of contact, marking the progress of this disintegration.

In the trials which I have at different times made on it, the greatest force that three persons could apply to it was sufficient to make its outer edge describe an arc whose chord was $\frac{3}{4}$ of an inch at 6 feet distance from the centre of motion. When suffered to return it vibrates for a few seconds before it falls again to rest. A force of a very few pounds is however sufficient to bring it into a state of vibration, and to maintain a visible motion. Even the wind blowing on its western exposed surface produces this effect in a very sensible degree. It is the largest of its kind at present moveable in Cornwall. I made an attempt to ascertain its weight by measurement. It may without much inaccuracy be resolved into two frusta of pyramids, on a common trapezoidal base, their union forming an irregular four-sided prismatic figure, 17 feet in length, and $32\frac{1}{2}$ feet in circumference about the middle part. Comparing the solid content of the stone, as deduced from this approximated measurement, with the sp. gr. of the granite of which it is composed, the weight appears to be 65,8 tons, a deduction if not precise, sufficiently accurate at least to satisfy general curiosity.

It would be superfluous to combat the opinion of those, who like the Iconocolasts of Cromwell's time, in the instance of the rocking stone of Merramber, fancied these stones to be the productions of art directed to religious purposes. The accidental coincidences which give rise to their formation, will be considered when I have reviewed the other tors which are the subject of this paper.

The Cheese-wring, (Pl. IV.) of which the second drawing is a representation, occupies the highest ridge of a hill to the north of Liskeard, one of that collection of hills which decline from Rough-tor, and Brown-willy, and which form the most elevated part of Cornwall. The summits of all these hills are covered with granite cairns in different states of ruin and disintegration, and their sides are strewed to great distances with the bowlders which have fallen from them at different times.

The migration of stones is here readily to be traced upon a scale easily comprehended The granite of which these hills are composed is well known, and has been often described.

It is not far from the Cheese-wring that the first traces are found of the asbestos and steatites which are known to be so abundant and conspicuous in the parish of St. Cleer.

The inspection of the drawing will show that this remarkable cairn consists of five stones, of which the upper ones are so much the largest as to overhang the base on all sides. The collective height of the whole pile is about 15 feet, from which compared with the drawing, the sizes of the different masses composing it are easily appreciated.

The rounding of the angles in this instance, has proceeded in some parts so far as almost to give an appearance of convexity to the touching surfaces from certain points of view; a state which once attained will speedily compel the Cheese-wring to join its former companions in the plains below. It is evident enough, that the cairn of which this is now the only remaining memorial, has been of considerable dimension.

An abstraction of its support, occasioned probably by the gradual disintegration and sliding of the summit of the hill, has permitted the lateral parts to fall away, leaving, in its present whimsical position, that part which happened to be best poised. It is unnecessary to suppose that the chisel of Druidism has been employed to reduce it to an image of Saturn. Natural causes are sufficient to account for its appearance. Dr. Borlase reports that the upper stone of this pile had been a logging stone, and thus attempts to strengthen his Druidical system. It would doubtless be a great improvement on the statue of Saturn, to be furnished with a moveable head, but an inspection of the upper stone is sufficient to show that its centre of gravity is placed much too high to admit of the conditions requisite for the production of that effect.

The last of these tors which I have chosen for the purpose of this illustration, is the Vixen Tor on Dartmoor. (Pl. V.) There is nothing extraneous or traditional connected with this rock to render it an object of interest in any other point of view than that for which I have selected it.

The granite of this county is known to be in general split by fissures in different directions, but most commonly tending to the perpendicular and horizontal. By those it is divided into masses of a cubical and prismatic shape. Of the exceptions to this rule there is one among many other instances, in Shaugh rick near Plymouth. If we examine a rock of this kind near the surface of the soil, we shall find that the fissure is a mere mathematical plane, separating the two parts, and that the angles are sharp and perfect. If we turn our attention to granites which from their greater elevation above the present soil appear to have been longer exposed to air and weather, we shall find, as the first step to change, a gentle rounding of the angles, such as is exhibited in the drawing last cited, the Vixen Tor. By degrees the surfaces which were in contact become separated to a certain distance, which goes on to augment indefinitely. As the wearing continues to proceed more rapidly near the parts which are most external, and therefore most exposed, the masses which were originally prismatic acquire an irregular curvilinear boundary, and the stone assumes an appearance resembling the pieces which constitute the Cheese-wring. If the centre of gravity of the mass chances to be high and far removed from the perpendicular of its fulcrum, the stone falls from its elevation, and becomes constantly rounder by the continuance of decomposition, till it assumes one of the various spheroidal figures which the granite bowlders so often exhibit. A different disposition of that centre will cause it to preserve its position for a greater length of time, or in favourable circumstances may produce a logging stone.

It is not necessary to call in the aid of long continued friction or distant transportation to account for the rounded form of these granite bowlders. The changes which they undergo in their places of rest, by their more rapid disintegration at the angles than at the sides, are sufficient to prove that this spheroidal shape may be produced by chemical action of air and water, without the necessity of any mechanical violence. However difficult it may be to give a very satisfactory account of this peculiarity, the fact is undoubted.

There is less difficulty in accounting for their separation from each other at their surfaces of contact, after the fissure has been formed, if we consider that they are liable to lodge water where the surface is horizontal, or to detain moisture where it is vertical.

That the wearing of these granites on the surface arises from the action of water, will be evident on examining the stones themselves, and the result of their disintegration. Wherever a stone is disintegrated by the most usual process, the oxidation of the iron which it contains, a change may always be observed to have taken place from the surface downwards to a more or less considerable depth in the stone. Sometimes even the whole mass of rock will appear to have undergone this gangrenous process at once, and to have become a bed of clay and gravel. But in the case of the granite now under view, it is evident that the change is merely superficial, and that no process of oxidation has taken place. Indeed, many of the varieties of which the mica and felspar are nearly white, contain so little iron that they are hardly subject to decomposition from this cause, however much they may, in such particular cases as that of the St. Stephen's granite, resolve entirely into gravel and porcelain clay. The most satisfactory proof however that the mere agency of water is sufficient to disintegrate this granite, is presented by those objects which perhaps in consequence of the Druidical speculations of Dr. Borlase are best known by the name of rock basons.

On the flat surfaces of these stones are frequently to be observed excavations, assuming some curved figure with rounded bottoms. Occasionally they are circular in their boundary, and as regularly spheroidal internally as if they had been shaped by a turning lathe.

They are of various depths, and they may be sometimes observed to communicate with each other. Their artificial appearance was sufficient to convince of the truth of his system regarding them, this strenuous supporter of a worship which must on his hypothesis have required a priesthood sufficient to exclude all other population, if every rounded cavity which the granite exhibits was a pool of lustration.

Their true origin is easily traced by inspecting the rocks themselves. On examining the excavations, they will always be found to contain distinct grains of quartz and fragments of the other constituent parts of the granite. A small force is sufficient to detach from the sides of these cavities additional fragments, showing that a process of decomposition is still going on under favourable circumstances. These circumstances are the presence of water, or the alternate action of air and water. If a drop of water can make an effectual lodgment on a surface of this granite, a small cavity is sooner or later produced. This insensibly enlarges as it becomes capable of holding more water, and the sides as they continue to waste, necessarily retain an even and rounded concavity, on account of the uniform texture of the granite. In time, the accumulated gravel is blown away by the winds, although in the deeper hollows it may often be found forming considerable accumulations.

The same solubility of granite in water, (to speak generally) is the cause of that wasting of the surface which these rocks undergo, and to which I have before attributed the enlargement of the vacuities at the surfaces of contact, and the separation of the prisms into detached masses.

We need not hesitate in admitting the solution of granite in water to an extent capable of producing this effect of disintegration, since we know that silex is soluble in that fluid by natural means, however we have been unable to imitate the process in our laboratories. It is also not improbable, that the quantity of potash which enters into the composition of felspar, may confer on it a similar property, and that even in a greater degree, although direct experiments are wanting to prove this fact. Whichever of these bodies is acted on in the case of this disintegration, the quantity of matter actually dissolved is probably very little; we can even conceive it possible that the mere alternation of the states of moisture and dryness, combined with frequent changes of temperature at the surface, may be sufficient to produce this effect without any actual solution of the substance of the rock. It is a matter of more difficulty to assign the cause of the change of figure which the masses undergo, by what process Nature " mutat quadrata rotundis."

Whatever disputes and doubts may have existed relating to the stratification of granite in general, I believe there is no one now who conceives the granite of Cornwall more than that of Arran or Mont Blanc to be stratified. The favourers of different hypotheses, must each be allowed for the present to adopt the opinions which to them seem the best founded, and it must depend on the conclusions which shall ultimately be adopted, relative to the aqueous or igneous origin of granite, whether these fissures are to be considered as the effects of contraction produced in the mass by the evaporation of water, or by the abstraction of heat. The cause of their peculiar form remains for the present involved in the same difficulties which attend on the more regular prismatic figures found in the trap rocks. But the fissures themselves having been formed in whatever way we chuse to suppose, we have still a difficulty unsolved, and that is the tendency which they exhibit to wear more rapidly on the angles and edges than on the sides, and thus to assume the spheroidal forms which facilitate the ultimate ruin and migration of the summits.

That this would be the consequence of a gradual action merely mechanical is undoubted, as the mass must ultimately acquire that figure which, being the last result of the action of decomposition is the one which will offer the greatest resistance to further change. In a chemical view, the same must also to a certain extent hold true; since any given particle, supposed cubical and placed at the angle or edge, will be exposed to the action of the solvent on two or more surfaces, while that on the side of the mass is exposed but on one, hence the angular body must ultimately change its figure, and approximate to a spheroidal form: it is easy however to see that the influence of this cause will be retarded in a quickly increasing ratio, and that it is insufficient to account for the extreme change of form suffered by granitic masses. If it were sufficient in the case of granite, it should equally produce in sandstones of prismatic fracture a determination to the spheroidal form. But in these we see that the process of superior waste at the angles and edges, soon ceases to produce an effect in modifying the figure of the mass, and that sandstone never assumes the decidedly spheroidal forms which are exhibited by granite. Mechanical causes of change are here out of the question. If we now suppose the hardness of a mass of granite, or its resistance to the disintegrating power of air and water, to vary in any given ratio at certain distances from the centre, it is evident that the effect of chemical action on the surface, will be to change the figure of that mass, and that the ultimate effect will be to disclose the sphere inscribed within that cube. Let us consider how far the facts bear us out in this supposition.

De Luc has observed in his Geology, that granite sometimes decomposes into spheroidal forms, and he describes piles of this rock in Silesia, resembling, as he says, Dutch cheeses. I need not quote more authorities for a fact witnessed by innumerable observers. In our own island of Arran (that little abridgement of the world) nodules of spherical granite are found in the valleys which descend from Goat-field, decomposing on the surface in crusts, and marking decidedly the very construction which my supposition requires, in a much greater degree than is requisite for the purpose. Similar granite balls have been seen in other places, so that their existence is well ascertained, and this is one of numerous instances, where the decomposition of a rock gives us most useful information with regard to its structure, and where without that aid, we should never have divined the secret of its formation. It is certain that these balls, now rendered spherical by decomposition, have been quadrangular masses, and hence we may step, without any great hazard of unsound footing, to this general conclusion, that these masses of granite, which show marks of wearing on their surface with rapidities proportioned to their distance from a central point, have had their hardness, and probably their crystallization or formation, determined from that centre.

The analogy of this circumstance to the similar balls formed in basaltic rocks is illustrative of both the cases, and probably both will equally tend to confirm the opinions which have been held relating to the igneous origin of these substances. Thus, if for the sake of argument I may be allowed to assume that granite is of igneous origin, it will be easy to explain the peculiar appearances exhibited by that *formation* of granite, which, like those of Cornwall and Arran and many others, is separated into cuboidal masses.

Here we must conceive, that in a homogeneous mass of fluid matter, crystallization had commenced from numerous centres at the same time. While there was yet space for the formation of successive solid deposits round any set of these imaginary centres, a spherical or spheroidal figure would be the result. As the surfaces of these spheroids approached each other, the successive crusts would interfere, and the remaining intervals would be filled by portions of spheroidal crusts, until the cuboidal figures of all the contiguous masses were completed, thus forming that aggregated mass of cuboids, which we witness in the granites of this aspect which remain uninjured in their places. We need not be surprised that this regularity is not more constant, nor the forms more perfect, as we are unacquainted with the numerous circumstances which may determine the several centres of crystallization, or which may interfere with the ultimate regularity of the resulting masses. It is certain from chemical experiments, that the fact which is the basis of the foregoing supposition, occurs in various instances of the cooling of slags and of rocks artificially fused, as Mr. Watt's experiments have so well shown. But in these experiments, certain as they are, we are unacquainted with the causes which determine the places of the several centres of crystallization, and though equally unacquainted with those which may have influenced the centres on which the granite masses were formed, we may yet from analogy understand how the irregularity of these masses may have been caused by a corresponding irregularity in the position of their centres.

We can also easily conceive that in certain cases, the peculiar circumstances of which lie equally hid from us, the approximation of the spheres of crystallization may have caused the crystalline polarity of the several masses to interfere with each other, so as to have produced in many cases an irregularity still greater than this, and in some instances even entirely to have obliterated the appearance of central tendencies. To the chemical facts above adduced in support of this explanation, I might subjoin, what every one's mind will immediately suggest, the illustration which the commenced spheroidal forms of the Cheshire rock salt, and the igneous explanation of the forms of basaltic columns, add to this supposition.

On a smaller scale, a phenomenon of rare occurrence in Nature may also be suggested in aid of it. I mean the spherically disposed granite of Corsica, which exhibits the various constituents of granite formed round numerous centres, and producing those beautiful specimens still so rare in the cabinets of collectors. Similar radiating tendencies in the smaller parts have been noticed by Saussure, and although I had not the good fortune to see them in Arran, my friend Professor Jameson has described them as existing there. I have also witnessed a similar disposition in the mica which is included in the granite veins near Portsoy, and the same structure is well known to exist in that variety of granite which is called Tyger granite, where the hornblende or shorl forms radiating spheres.

It is sufficiently apparent from the history of this granite, and from its progress in decomposition now described, that the migration of stony masses may to a certain extent be explained, at least as far as this variety of granite is concerned, even without having recourse to any very violent mechanical action. But the decision and complete explanation of this very common and puzzling phenomenon, must in most cases rest upon a question of a different nature, and of greater difficulty, namely, the alterations which the surface of the earth has undergone at different eras, as well as the comparative antiquity of those changes. This phenomenon is only one of many, which prove the former existence of a different distribution of those parts of the globe which are at this present time land and sea, hill and valley.

IV. *Notes on the Mineralogy of the neighbourhood of St. David's, Pembrokeshire.*

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THE following notes are arranged under separate heads, descriptive of particular points of the country adjacent to St. David's, which were visited during a stay of a few days at that place in the summer of 1811 : and for obvious reasons, such points were selected as might from description be easily referred to by others inclined to examine the same ground.

No order has been adopted in the distribution of these heads than was required for the convenience of description; for there did not on the spot, and to an unprejudiced observer, appear to be any obvious and natural chain of connexion between the several points here described.

The country round St. David's, when viewed from an eminence, presents the appearance of an extensive uneven plain, interspersed with numerous detached hills or rocky summits of an irregularly conical shape. The rocks which constitute these hills bear no marks of regular stratification; rarely support even a slight degree of vegetation; and when compared with the surrounding surface, appear as so many nuclei, about which is arranged a very curiously diversified series of highly inclined strata of a kind of slate. The constituent parts of these insulated rocks are felspar and hornblende;

and the general character of them is crystalline: but the felspar rarely if ever occurs in distinct crystals; and even the hornblende, though usually the most accurately defined of the two, is sometimes not discernible from the felspar. Again, though the mass often appears upon the whole to have been of chemical origin, yet at the same time it is, partially, of a structure to the eye decidedly mechanical; and in some instances the character is so extremely equivocal as to leave the judgment in a very difficult state of suspense. The predominating colour of these crystalline rocks is a brownish green.

The two highest of these hills, called Carnllidy and Penberry, are situated to the north of St. David's: they rise less abruptly from the plain than the similar hills of the neighbourhood; and are in a manner connected with each other, and with a third summit not far distant from the last mentioned, by a slightly elevated ridge which passes in a south-westerly direction from one hill to the other; Penberry being at its north-eastern extremity. From the summit of Carnllidy the ground gradually slopes towards the west for a few hundred yards, and then, again rising, forms the promontory called St. David's Head.

The ascent to the two hills above mentioned, both on the north and on the south side, is formed by highly inclined strata of a slaty rock which would be commonly called grau-wacke, a term in the present instance used only for the purpose of general description; and the nearly precipitous cliffs, by which the greater part of the adjoining coast is bounded for some miles, appear to consist principally of the same kind of rock. The massive tabular laminæ of this schist rise abruptly from the sea, with a highly elevated degree of inclination towards the land, over the edge of which they are sometimes folded in the form of a broad mantle, or are occasionally broken into natural arches and caverns; giving to the outline of the cliffs which they compose a bold but graceful curvature, very characteristic of a coast of this kind, and productive of scenery the most magnificent. A very striking illustration of this effect, though it is not clear whether it proceed from rocks of this class or from those more immediately belonging to the coal grits, occurs at Saunders' Foot, a small cove situated about four miles to the north-east of Tenby.

It not unfrequently happens that the partial removal of the superincumbent laminæ of the schist, from the surface of those placed relatively beneath them, has given rise to that appearance of a succession of broad flat steps or stairs which suggested to the Swedish mineralogists the term Trapezius; a term applied by them to that class of rocks, in which from the action of the weather and other causes, there is a tendency to assume an appearance of this kind.

These slaty strata are occasionally traversed by beds of clay porphyry; and by veins of quartz affording very large and beautiful specimens of rock crystal.

It is worth noticing that in none of the stratified or unstratified rocks of this neighbourhood, did the extemporaneous test of an acid give any evidence of the presence of carbonate of lime: nor did there occur in them, with the exception of one equivocal instance, the smallest trace of any organic remains.

St. David's Head.

The rock which forms this promontory consists of a mixture of blackish green hornblende and white felspar; but the proportion of the hornblende often so far predominates, and its crystalline form is so regularly developed, that the felspar appears rather as an accidentally connecting medium of the former, than as an essentially constituent part of the whole rock. The crystals of the hornblende, though generally small, sometimes exceed two or three inches in length; in which instances they are not of a proportional breadth: in general also they are closely compacted with the body of the rock; but occasionally, and especially when larger than usual, they are easily separable from the mass, leaving a smooth impression of their surfaces. These impressions, as well as the crystals themselves, have commonly a dull iridescent semi-metallic lustre; arising, perhaps, from an increased oxydation of the iron of the hornblende, which by loosening the attachment of the crystals to the mass in which they are imbedded, has disposed the compound to assume that regularity in its fracture. A similar appearance often presents itself in parts of the Malvern rock; and it is probable that the kind of lustre here noticed is very characteristic of peculiar states of hornblende, and may serve to ascertain its presence in a compound rock where no traces of its crystalline form are evident.

Carnllidy.

The hornblende of the summit of this hill is indistinctly crystallized, and of a dark and dull olive green colour; generally very uniform in its character; and so closely compacted with the felspar that the fracture passes indiscriminately through both. The rock itself is remarkably hard, and has that degree of toughness which is characteristic of the class of rocks called by Wallerius Saxa Cornea, and Corneus Trapezius; which rocks, as may be collected from the volcanic dissertations of Dolomieu and Ferrara, contain hornblende as a principally constituent part. It occasionally contains particles of pyrites; and insensibly passes into a greyish green coarse and soft slate, which in the mass is remarkably disposed to separate into flat rhomboidal fragments, the surfaces of the laminæ of which are sometimes interspersed with a few small specks of white mica.

Penberry.

The rock constituting this summit, as may be satisfactorily ascertained by insensibly graduating specimens, is of the same nature with those already spoken of; though at first sight, and especially in particular parts, apparently very different. The hornblende gradually dsminishing in its proportion, or being intimately blended with the substance of the felspar, often merely imparts an obscure shade of green to the whole mass; the presence of which colour principally assists the eye in recognizing the true nature of the rock; and but for which it might be confounded with a compact sandstone or felspar. The same observation holds, but still more strongly, with respect to the rock on which stands Roche Castle; a ruin situated to the north of the turnpike road, about half way between Haverfordwest and St. David's. This rock has, much more decidedly than Penberry, the character of a compact sandstone: but in its geographical relation to the surrounding country, it exactly corresponds with the preceding rocks, and with the numerous similar rocks of the neighbourhood. However this may be, the surface of the ground between Roche Castle and St. David's is scattered over with numerous large boulders, as they might be called, very closely resembling in their general character one or other of the three rocks already described; and all of them bearing strong marks of having been the result of chemical formation.

The rock of which Penberry is composed shews occasionally a slight tendency to concentric disintegration; and the external part of it is here and there altered by the action of the weather, after the manner of ferrilite.

On the coast, a little to the north-east of Penberry, is a slate quarry; worked out of a mass of schist, which forms remarkably bold and nearly perpendicular cliffs, the strata of which are occasionally much contorted. The surfaces of the laminæ of the slate have sometimes an ochry tarnish, and abound with minute particles of mica.

St. David's Slate Quarry.

This quarry is situated between St. David's Head on its north, and a beach called the White Sands on its south side. The slate is of nearly a black colour, and is here and there traversed by veins of brownish white compact and indurated clay, containing tarnished cubical crystals of iron pyrites. The slate is employed in roofing; but does not thoroughly resist the action of the weather, perhaps from the effect produced on pyritical matter disseminated through it: wherefore it is customary in all this part of the country to white-wash the roof as well as the walls of their houses.

The laminæ of this slate are sometimes wrinkled or wavy. It contains but faint traces of mica; and sometimes approaches to the character of siliceous schist.

The White Sands.

This name is given to a beach of about one-third of a mile in length, which at its northern extremity is separated from St. David's slate quarry, by a low and narrow ridge of rocks projecting into the sea; and is terminated at its southern extremity by high cliffs. Towards the land it is bounded principally by heaps of sand; interspersed with low rocky cliffs, which rise higher and higher in advancing to the southern extremity; at which point the rocks are particularly interesting from their variety; passing, sometimes abruptly, from the coarsest grained conglomerate, as from its appearance it might be called, to the finest schist.

The prevailing colours of these rocks are green and brownish purple; those colours alternating occasionally as in striped jasper. The cement of those parts which resemble a conglomerate appears to be in a great measure of chemical origin; containing minute crystals of semitransparent felspar, with small particles of glassy quartz. It seems worthy of remark, that in those parts of the rock which resemble a conglomerate, the pebble-shaped nodules of quartz are very frequently of the same purple colour as the schist. The sand of this beach when viewed through a microscope is seen to be a mixture of fragments of shells with small particles of variously coloured quartz and slate. A portion of it weighing 200 grains, which had been collected in July 1811, and had been kept in a room without a fire till March 1812, only lost one grain of its weight by exposure to a heat of 212°: after which, having been boiled in diluted muriatic acid, and then filtered, washed, and dried by the same heat, it weighed 157 grains; having lost $\frac{42}{199}$ or rather more than $\frac{1}{5}$ of its weight, which may be considered as very nearly the proportion of calcareous carbonate contained in this sand. The sand is extensively used as a manure.

Porthclais.

This is a small fishing harbour situated to the south or south east of St. David's, and is the termination of a narrow shallow valley, which extends two or three miles inland, and is longitudinally divided by the river Alun; the mouth of the river emptying itself into this harbour.

The rocks constituting the rising ground on the left bank of the mouth of this river appear to be a compound of felspar or quartz, or both, with hornblende: the predominating colour is brownish white, arising from the great proportion of the two first mentioned component parts.

On the right bank of the mouth of the river the strata are distinctly schistose, and very various in their appearance. Within the distance of two feet the rock assumes the following characters.

Brick red slate, nearly siliceous.

Brownish purple slate, with streaks of green.

Red slate, with an incrustation between some of the laminæ resembling blackish green scaly chlorite.

Greenish grey compact sandstone.

Stratified sandy slate, partly greenish grey, partly purple.

Traces of steatite and serpentine occur in the rocks of this neighbourhood.

Rock in the Close of the Cathedral.

The cathedral is situated in a part of the narrow valley through which the river Alun winds from the north east; the descent to its eastern and south eastern extremity is steep, and is formed by a rock which might be called a small grained green-stone porphyry, in a high state of disintegration.

The general colour of this rock varies between a brownish white or yellow, and a very obscurely greenish brown: where most compact it has nearly a homogeneous appearance, and would by many be described as a soft compact felspar; but commonly it is in a very loose state of aggregation.

Parts of this rock resemble Fullers' earth; but from the occasionally green colour and the peculiar direction of the natural rifts, giving it a tendency to separate into rhomboidal or into wedge-shaped fragments, it possesses a characteristic mark which serves to connect it with the prevailing rock of the neighbourhood.

Many parts of this rock easily crumble into the state of an earthy gravel, and are commonly used as a substitute for common gravel in and about St. David's.

I shall readily be excused for mentioning here, that there is in the Ashmole Museum a specimen from Jersey so very like in its general character to the part of the St. David's rock now under consideration, that even an experienced eye might be deceived as to its separate identity: and it adds to the interest of the comparison of the specimens in question, that they both occur amongst a suite of rocks composed principally of hornblende and felspar, and are both used for the same economical purpose.

Fortification near St. David's.

To the south west of St. David's are the remains of an old entrenchment, situated near the edge of the adjacent cliff; and from the further extremity of the entrenchment the cliffs run out at right angles to the general bearing of this part of the coast, forming a tongue of land which projects into the sea. In this projecting point a natural arch exists, which has been probably excavated by the gradual washing away of part of the rock; presenting an appearance somewhat like that represented in the third of Dr. Mac Culloch's plates, in the first volume of the Society's Transactions.

Near the extremity of this tongue of land is a vein of clay porphyry of a light drab colour, containing small crystals of felspar nearly of the same colour, together with completely tarnished cubical crystals of iron pyrites: there is also in this vein an occasional appearance of decaying hornblende or chlorite. The base of this porphyritic vein wears away by the action of the weather, and leaves the crystals of the felspar projecting from the surface of the weathered part.

This vein of porphyry is inclosed in a stratum of friable schist, neither the character nor position of which are at all altered by the immediate contact of the vein. The adhesion between the schist and the vein is so very slight that it is extremely difficult, if at all possible, to separate a specimen which shall unequivocally shew the junction of the two.

The schist, which is traversed by filamentous veins of quartz, appears to the eye of a very delicately laminated structure, yet does not readily separate in the direction of the planes of the laminæ. The surfaces of many of the natural rifts have a brownish black tarnish.

Carvay.

The cliffs in the neighbourhood of this spot, the precise situation of which is not recollected, but it is not far distant from the foregoing, consist of highly inclined strata of indurated greenish-grey freestone; of red and coarsely laminated slaty freestone, which is used in building; and of a soft argillaceous freestone with numerous veins of sparry quartz. Traces of chlorite are very frequent in the rocks of this neighbourhood, and the slaty freestone is often interspersed with particles of a substance intermediate in its character to mica and chlorite.

Not far from Carvay I met with two insulated masses, one of which, bearing a very close resemblance to the mill-stone grit of Derbyshire, was made up of small particles of white and reddish-white semitransparent quartz cemented together by white earthy felspar: the other was also a kind of grit-stone, consisting almost entirely of particles of quartz, occasionally interspersed with specks of white earthy felspar. Though I saw no rock *in situ* to which these masses could be directly referred, yet as they did not much differ from some of the rocks of this district, excepting in the size of their component particles, and as there was not any ground for supposing they had been brought there by art, they probably belong to the suite already described.

Treginnys.

This is a broad headland, about three miles to the south-west of St. David's. It is frequented by trading vessels on account of a fresh-water spring which rises near the edge of the adjacent cliffs, beneath which is a convenient harbour.

The general character of the rocks in the neighbourhood of Treginnys is of that equivocal nature alluded to in the beginning of these notes: here and there they assume the appearance of a compact earthy felspar of an olive-green colour, and then probably often contain epidote, compact veins and crystals of which I saw in more than one instance. In one place this compact green rock occurs in angular columns horizontally aggregated, and forming a part of the cliffs on the north side of the harbour. The number of the columns is not above eight or ten; their form irregularly pentagonal, and their diameter less than a foot. This was the only appearance of the kind observed in the neighbourhood of St. David's.

The internal texture of many of the rocks about Treginnys, and in the road between that place and St. David's, resembles that of a very compact mechanical aggregate, the particles of which are however obscurely defined: the predominating colours are green, greenish-white and pale purple: the character of the recent fracture is like that of coarse steatite. A close inspection brings to view numerous crystalline surfaces of semitransparent laminated felspar, and particles of glassy quartz; and it is worth noticing that the felspar and quartz now and then occur in the substance of the imbedded particles as well as in the cementing medium, shewing a probably cotemporaneous formation of the whole mass.

Some of the rocks of this neighbourhood approach to serpentine in their general character, and contain veins of indurated steatite.

Ramsey.

This is by far the largest of a number of rocky islands lying off the coast of St. David's, and is separated from the main land by a channel of about two or three miles in breadth. The greatest extent of the island is from north to south, and at each extremity in this direction is an elevated summit, or beacon, of considerable height, the general character of each of which is similar to that of the corresponding summits on the main land. The intervening rocks are principally slaty. The western front of each of these two summits projects into the sea far beyond the intermediate space of land; and it appears probable that the bay interposed between the promontories has been cut out by the dashing of the waves against the crumbing schistus which is here opposed to them, and that consequently in process of time, as this schistus is extended across the island to the eastern shore, the island may eventually be separated into two.

The harbour of Ramsey is a small cove excavated in a mass of black schist, and situated near the southern extremity of the eastern front; advancing from which towards the west, and then ascending the southern beacon from its northern side, you pass over an apparently conglomerate rock made up almost entirely of large pebble-shaped masses of white quartz. From the uniformity of colour in this rock, and from its general appearance, a doubt at first sight arises whether it is really a mechanical conglomerate or the result of a peculiar chemical conformation.

On and near the summit of the southern beacon the rock in many places resembles coarse chert, from which it passes into the state of indurated clay containing small crystals of felspar and of dodecahedral quartz, the latter in general very imperfectly defined.

The composition of the rock forming the northern beacon is felspar and hornblende, sometimes assuming nearly a homogeneous appearance, and sometimes, though rarely, inclining to a porphyritic structure.

With the island of Ramsey these notes on the Mineralogy of the neighbourhood of St. David's terminate, in drawing up which it has been my object to avoid as much as possible the language of hypothesis, and to detail the appearances which I met with in terms strictly descriptive: and though I feel strongly persuaded, on grounds which have not been taken up hastily, that all the rocks which I have been describing are essentially allied to each other, and are all of chemical and cotemporaneous origin; yet, conceiving it would be improper on the present occasion to enter into the particulars or on the defence of those grounds, I think it respectful to the Society to be silent on those points.

I may however with propriety add, that from communications with very competent judges, aided by the inspection of specimens which they had themselves collected, it is clear to me that the geological phenomena above described are of very extensive occurrence. In Jersey and Guernsey for instance, in various parts of Devonshire and Cornwall, in North Wales and Cumberland, in the neighbourhood of Mount Sorrel in Leicestershire, in all these places severally, is found an assemblage of rocks of a decidedly crystalline character, and consisting of hornblende and felspar, associated with rocks either of a schistose structure or resembling a more or less fine-grained conglomerate, intersected not unfrequently by masses of a porphyritic character, and sometimes passing into serpentine.*

In the decidedly crystallized rocks of these suites, consisting of hornblende and felspar, the felspar sometimes predominates and is of a red colour, in which case the compound is usually, I believe, called sienite; but the same term seems justly applicable where the hornblende predominates and the compound is of a black or of a green colour, for the two varieties insensibly pass into each other.

The opinion which I have here ventured to express of the natural alliance between the various rocks above described is strongly supported by its correspondence with the opinion entertained by M. Godon respecting a similar class of rocks occurring in the

* The transition of the natural compound of hornblende and felspar into serpentine has been observed in Cornwall, and is satisfactorily shewn in specimens brought from thence and deposited in the Ashmole Museum; and the opinion of the natural alliance of these two rocks is strongly confirmed by the inspection of numerous specimens brought from the coast of Labrador and deposited in the same Museum.

vicinity of Boston in North America;* and should it ever receive general confirmation, it might I think be fairly applied to the correction of one part of the present nomenclature of Geology. I would in that case, for instance, propose that the term *sienite* should be generally applicable to the whole series, and that the slaty or granular forms of it should be specifically described by those epithets; and thus, in a few instances at least, we should attain the desirable object of banishing the term *grauwacke* from the language of mineralogy; a term not only offensive from its harshness but still more from its want of precision.

* There is a paper on this subject by M. Godon in the 15th vol. of the Annales du Muséum d'Histoire Naturelle, p. 455, the perusal of which will amply repay those who may be induced to read it.

V. *An Account of the Brine Springs at Droitwich*,

By Leonard Horner, F.R.S. M.G.S.

§ 1. THE town of Droitwich is situated nearly in the centre of Worcestershire, about six miles from Worcester, on the road to Birmingham. For a very long time* the manufacture of salt has been carried on to a great extent in this place, and as I am not aware of the existence of any detailed account of the natural and chemical history of the brine springs from which it is procured, I take the liberty of laying before the Society some observations which I made on the spot in October, 1810, together with the results of some experiments I have since made, with the view of determining the chemical composition of the brine.†

* In 816, Kenulph, King of the Mercians, gave Hamilton and ten houses in Wick, *with salt furnaces*, to the church of Worcester.

"At the time of Domesday Survey," which was finished in 1087, "the only fuel used for boiling the brine was wood, and the demand for it much greater than the neighbourhood of Droitwich could supply, especially as the brine was of a weaker quality in those days, and required to be boiled longer than it does at present."—Nash's History of Worcestershire.

† In the Philosophical Transactions for 1678, there is a short account of the salt-works of Droitwich by Dr. Thomas Rastel. At that time there were three pits made use of, the greatest of which was thirty feet deep. He found that the brine yielded above one-fourth of its weight of salt.

§ 2. The brine-pits are in the centre of the town, situated in a narrow valley, in the bottom of which runs the small river Salwarp. The sides of the valley rise rather abruptly from the river. Doder Hill, on the right bank, which appeared to me to be the highest of the two sides, I measured with the barometer, and found it to be about eighty feet above the bed of the river.

§ 3. The prevailing rock around Droitwich is a fine-grained calcareo-argillaceous sandstone, of a brownish red colour, with occasional patches and spots which are greenish blue. At Doder Hill, where a vertical section of it is exposed, it contains beds of a greenish-grey colour, and of a more indurated texture, but which do not appear to differ materially in composition from the red sandstone. These contain slender veins of crystallized gypsum, the forms of which are very distinct, where the widening of the vein has produced small cavities. I did not observe any gypsum in the red sandstone. The stratification is horizontal, and both the red and the grey rocks, where they are exposed to the air, crumble down into small pieces. I did not discover any traces of organic remains.*

This sandstone is the same as that which Mr. Aikin has described as occurring to so great an extent in Shropshire and Staffordshire, and which he considers to be the old red sandstone of Werner.† He has also stated that it is found in this district, but as he does not trace it to any particular spot beyond Droitwich, I may here observe, that it appears to me to be the same as that which I found on the banks of the Severn,‡ between twelve and thirteen miles from this place; and I have great reason to believe that it continues without interruption

* Dr. Rastel says, " I never observed any shells."—Phil. Trans.

† Trans. of the Geol. Society, vol. 1, p. 191.

‡ Trans. of the Geol. Society, vol. 1, p. 312.

throughout the whole of that extent, and even for some miles to the south of the spot I have just named.

Mr. Aikin observes that the red sandstone of Shropshire does not effervesce with acids: in this respect, therefore, it differs from that of Droitwich, for both varieties of the sandstone effervesce pretty briskly for a short time, but that which is of a grey colour appears to contain the greatest proportion of calcareous matter.

The extensive beds of rock-salt, and the brine-springs of Cheshire, according to Dr. Holland,* are situated in strata of a similar nature.

§ 4. The surface soil which covers the red sandstone, contains large pebbles, generally about the size and shape of a goose's egg, but often larger. Those which I examined consisted of compact bluish-grey quartz, very much resembling some varieties of flint and calcedony, and different varieties of coarse and fine-grained quartzose sandstones. These pebbles are not found in great quantity, for, as I was informed by a labourer, they are picked off the surface of the fields for the purpose of mending the roads, no spot having been found in the neighbourhood, where they are sufficiently abundant to pay the expence of digging for them.

§ 5. With regard to the nature of the rocks through which the brine-pits were sunk, I have not been able to obtain any very distinct information, as no new pit has been made for the last thirty years. All that I have in my power to lay before the Society on this subject, is the account contained in Nash's History of Worcestershire, together with some details I received from an inhabitant of Droitwich, who was on the spot at the time the last pit was dug. The following is the information given by Dr. Nash.

* Trans. of the Geol. Society, vol. 1, p. 38—See also his Agricultural Survey of Cheshire.

"Until 1725 the pits had not been sunk very deep, but in that "year the talc was sunk through, and soon after every one sunk "his pit through the talc, and obtained such a profusion of strong "brine that not one-tenth part of it hath ever been used, but ran to "waste. In 1773 Joseph Priddey, of Droitwich, informed me that "he had sunk several pits, and generally found it about 35 feet to "the talc, through the stratum of talc 150 feet, under the talc a "river of brine 22 inches deep, under this river a hard rock of "salt. When the hole is bored through the talc, the brine bursts "up with amazing violence to the surface of the ground. In the "year 1774 he sunk another pit, and found it to the talc 53 feet, "through the talc 102 feet, the brine river 22 inches, then a rock "of salt: he bored $2\frac{1}{2}$ feet into this rock, and found it still the "same. In 1779 a hole was bored previous to a brine pit being "sunk in the yard of Richard Norris, Esq. The strata were, "mould 5 feet, marl 35, talc 40, a river of brine 22 inches; "under the brine, talc 75 feet, and a rock of salt, into which the "workmen bored 5 feet.* I have been informed, likewise, by "persons employed in sinking these pits, that immediately above "the river of brine is a thin crust, easily perforated, and, next to "that, a very soft substance, perhaps two feet thick, and then the "talc. This talc, or rather gypsum, or alabaster, is a shining "fissile species of stone, of a whitish colour. It is so hard that "the workmen never sink the pit through it; they bore a hole,

* The account of the sinking of this pit differs so materially from the rest, that I suspect it must be inaccurate. In the accounts of the sinking of the other pits, the brine flows over rock-salt; but here 75 feet of gypsum intervene between the brine and the salt. As all the pits are situated within the space of a square furlong, it is not probable that so remarkable a change should take place in the relative position of the gypsum and the rock salt.

"four inches in diameter, through which the brine rises and fills "the pit."

I was informed by an old man who assisted in sinking Walker's pit, that they sunk through soil, gravel, red marly clay, blue and white stone, hard rock, and talc, and that they came to the brine at the depth of 50 yards from the surface; that for the first 15 yards they cut out a shaft, about 8 feet square, this they coated with clay, and afterwards lined with planks, to prevent the springs of fresh water, which are found at that depth, from mixing with the brine.* At this depth of 15 yards they found the hard rock, and they then bored a hole of about 4 inches in diameter through this hard rock until they came to the brine, which they found at the depth of 35 yards farther; when they came to the brine, the borer suddenly fell 22 inches, thus indicating the depth of it. As soon as the rock was penetrated, the brine rushed rapidly through the hole, the mouth of which the workmen were obliged to stop, until they got out of the pit. When the plug was withdrawn, the brine quickly rose to the surface and overflowed.

§ 6. Although the information contained in the preceding statements is not very precise, yet they convey a general idea of the nature of the rocks sunk through, and it is very probable that they are similar to those exposed at Doder Hill, immediately contiguous to the pits, and which I have already described. We learn, however, with tolerable certainty, that these springs are impregnated from a body of rock salt; and we obtain an additional testimony in support of the observation, that rock salt is invariably accompanied by gypsum. From the rapidity with which the brine rises to the surface,

* In different places in the town of Droitwich, the water in the wells is brackish, while in others, that are sunk to the same depth, it is quite fresh.

it is evident that the source of these springs must be situated in much higher ground than that in which the pits are sunk.

§ 7. There are several pits on both sides of the river, but chiefly on the south side. The greater number of them, however, are not used, and the whole of the present extensive works are supplied from four pits.* Indeed, the quantity of brine that is used bears but a small proportion to that which is allowed to run to waste; for, except when the reservoirs are filling, the brine is constantly flowing into the adjoining canal, through a channel cut for the purpose, near the mouth of the pits.

§ 8. The four pits that are worked at this time are distinguished by the names of Walker's Pit, Walwyn's Pit, Romney's Pit, and Stuckey's Pit. From each of these I obtained a bottle of the brine, for the purpose of submitting it to chemical examination. I also procured a bottle of the brine from Farley's Pit, on the north bank of the river, but which is not now worked.

I shall now lay before the Society the details of the process I adopted in this analysis.

Analysis.

§ 9. The brine from all the pits is perfectly limpid, and when held in a tumbler is colourless; a greater body of it, however, has a pale greenish hue, similar to that of sea-water. It has remained equally clear at the end of a year and a half in a bottle closely corked,

* Through the kindness of Thomas Farley, Esq. the principal proprietor of these works, I have learned, that the quantity of salt, annually made at Droitwich, is about 16,000 tons.—The principal part of this is consumed in England, and pays a duty of about £320,000.—The present market price of the salt is £31 per ton, £30 of which is duty.

and no change of transparency was produced, when left exposed to the air in an open vessel, for several days.

Its taste is intensely saline, but without any degree of bitterness; neither is there any bitter taste in the crust which is deposited at the bottom of the pans, after several successive portions of brine have been evaporated.

The temperature of the brine in the pits, a few feet below the surface, differed very little from that of springs in general. It was 55°.*

§ 10. *Specific Gravity, and Amount of the solid Contents.*

The specific gravity of the several brines I found to be as follows:

Walker's pit, ...	1206.11†
Walwyn's pit, ...	1203.83
Romney's pit, . . .	1200.15
Stuckey's pit, ...	1184.67
Farley's pit, ...	1174.71

* I omitted to note down the temperature of the air, but it was a warm day for the season of the year.

† This is not an absolutely saturated solution, for by adding salt to the brine at a boiling heat, and allowing it to cool to 60°, I obtained a perfectly limpid solution of the specific gravity of 1210.39. This sp. gr. almost exactly corresponds with that of Hassenfratz, An. de Chemie. vol. 28, p. 298. In the sixtieth volume of the Philosophical Trans. Dr. Watson, the present Bishop of Llandaff, has given a valuable paper, entitled, "Experiments and Observations on various Phenomena attending the Solution of Salts."—He has constructed a table of the specific gravity of water impregnated with different quantities of common salt, from $\frac{1}{3}$ down to the 1024th part of the weight of the water, at a mean temperature of 50°. The salt used was sea-salt, of the finest kind, and extremely dry.

The highest specific gravity which he gives, is 1206, which very nearly corresponds with that of Walker's pit; but from what has been said above this is not the specific gravity of a fully saturated solution.

Four cubic inches of brine were evaporated to dryness very slowly, in a heat which was not suffered to rise above 212°, and towards the close of the evaporation it was kept between 170° and 180°. The residuum was reduced to powder, and again kept for an hour in a heat of about 180°. The different brines yielded the following quantities of entire salt.

Walker's pit,	. . 317.14 grs.	= 2289.75 grs. in a pint.
Walwyn's pit,	. . 313.40 —	= 2262.75
Romney's pit,	. . 311.00 —	= 2245.42
Stuckey's pit,	. . 283.50 —	= 2046.87
Farley's pit,	. . 266.34 —	= 1922.97

This variation in the strength of the different brines is probably owing to the mixture of the fresh-water springs in different proportions. Farley's pit, which is the weakest, is perhaps so on account of the brine not being agitated by pumping, whereby the lighter fresh water will only mix with the brine in the upper part of the pit: the bottle of it which I obtained was from near the surface.

But a solution of this specific gravity he states to contain $\frac{1}{3}$ of its weight of salt; whereas I have found (B. a.) that three ounces of the brine of Walker's pit, weighing 16284 grs. yielded only 431,86 grs. of salt, which is not equal to two-sevenths of the weight.

The difference between the results which I have obtained, and Dr. Watson's tables, (if it is not owing to error on my part,) may probably arise from the degree of purity of the salt which he used, and also from the state of it with regard to dryness, before it was added to the water.

Dr. Holland, in his Agricultural Report of Cheshire, states, that salt, after as much water as possible has been previously drained from it, loses about one-seventh of its weight, when heated and dried before the fire, without being allowed to decrepitate.

§ 11. *Preliminary Experiments with Reagents.*

a. Tincture of red cabbage—no change produced.*

b. Litmus paper—no change.

c. Turmeric paper—no change.

d. Lime water—no change.

e. Nitrate of barytes—a considerable white precipitate.

f. Oxalate of ammonia—a white precipitate.

g. Ammonia—a slight turbidness.

h. Neutral carbonate of ammonia—a white precipitate. This was separated by filtration, and on the addition of phosphate of soda to the clear liquor, a slight turbidness was produced, and, after a little time, a rod drawn along the glass vessel left white streaks.

i. Succinate of ammonia—no change.

k. Tincture of galls, a turbidness, but no blackness.†

l. Prussiate of potash—no change, even after the addition of muriatic acid.

m. After the brine was boiled briskly for some minutes, it remained perfectly transparent, and had deposited no sediment.

The brine, therefore, does not contain any uncombined acid, (by Exp. *a. b. d.)* nor uncombined or carbonated alkali, (by Exp. *a. c.)* nor earthy carbonate or oxide of iron, (by Exp. *m.)* nor iron in any other state of combination, (by Exp. *i. k. l.)*

As a farther proof that it does not contain either an earthy carbonate, or oxide of iron, the crust left at the bottom of the pan

* This experiment was made on the spot.

† This turbidness was evidently owing to the alcohol of the tincture.

after the evaporation of successive portions of the brine, called by the workmen *pickings*, and of which I procured specimens, is entirely soluble in water.

The brine appears to contain, besides muriate of soda,

1. A sulphate, or sulphates, (by Exp. *e.*)
2. Lime, (by Exp. *f.*)
3. Magnesia, (by Exp. *g. h.*)

The sulphuric acid may be in combination either with lime, magnesia, or soda, or with all the three.

The lime and magnesia may be in combination either with sulphuric or muriatic acid, or with both.

§ 12. These preliminary experiments were made upon the brine from the five different pits; and as all the specimens gave the same results, I considered it only necessary to determine the proportions of the several ingredients in one of them. I employed for this purpose the brine from Walker's pit, as being the strongest.

A. *To determine the Amount of the Muriates.*

From one ounce measure of brine weighing 542.8 grs. I precipitated the sulphuric acid by nitrate of barytes, separated the precipitate, and washed it with distilled water, until no change was produced in the washings by nitrate of silver, and taking care to add all these washings to the brine. I now precipitated the muriatic acid by nitrate of silver, which last I added in excess. The muriate of silver was washed with distilled water until no change was produced in the washings by muriate of soda. It was then dried in a low sand heat over a lamp, until it became of a purple hue throughout. It now weighed 339.63 grs. which is equal to 64.7 grs. of acid, taking the composition of muriate of silver to be 19.05 acid and 80.95 base, according to the determination of Dr. Marcet, and which, from its close coincidence with that of Gay Lussac, appears most entitled to confidence.

B. *To separate the Earthy Muriates.*

a. Three* ounce measures of the brine, weighing 1628.4 grs. were evaporated to dryness in a heat not exceeding 200°, and which was reduced to 180° towards the close of the operation. The residuum was reduced to powder, and again exposed to a heat of about 180° until no farther moisture was given off. It now weighed 431.86 grs.†

b. This residuum finely powdered, I put into a flask, and poured on it two ounce measures of alcohol nearly boiling. It stood forty-eight hours, during which time it was frequently shaken. It was then filtered, and the salt left on the filter was washed with two ounces of fresh hot alcohol.

c. The filtered liquor was evaporated to dryness in a very gentle heat, and a small quantity of fresh alcohol was added to the residuum, to separate the earthy muriates from the muriate of soda taken up by the alcohol in the process *b.* This was filtered, and the liquor being evaporated to dryness yielded 0.32 gr. of residuum.

* As all the other salts, besides the muriate of soda, were shewn by the preliminary experiments to exist in comparatively small quantities, I used a larger proportion of the brine in the determination of these, to avoid as much as possible the errors of too minute manipulations.

† So that the brine contains 26.53 per cent. of salt.

d. This residuum was dissolved in distilled water, and as it was unnecessary to attempt to ascertain the proportions of muriate of lime and muriate of magnesia in so small a quantity, supposing them both to be contained, all I could do was to determine the existence of each.

e. To one portion of this solution I added oxalate of ammonia, which produced no change.

f. To another portion I added pure ammonia, which immediately occasioned a flocculent precipitate.

g. To a third portion I added neutral carbonate of ammonia and phosphate of soda; a precipitate was produced, and a rod drawn along the glass left white streaks.

The whole therefore of this residuum was muriate of magnesia, with perhaps a minute quantity of muriate of soda.

C. *To estimate the Amount and Nature of the Sulphates.*

a. To three ounce measures of brine, weighing 1628.4 grs. I added nitrate of barytes in excess. The precipitate was well washed, dried over a lamp, and afterwards heated to redness in a platina crucible. It weighed 22. grs. which is equal to 7.37 grs. of acid, or 2.46 grs. in an ounce; according to the proportions of Berthollet,* of 33.5 acid and 66.5 base in 100 parts of sulphate of barytes.

This acid might either be combined with lime, magnesia, or soda, or with all the three. To determine what it was combined with, I dissolved the salt which had been freed from the earthy muriates by the process B. *b.* in distilled water.

* Memoires d'Arcueil, vol. ii.

b. To this solution I added oxalate of ammonia in excess: the precipitate after being well washed, and dried in a heat not exceeding 165°, weighed 5.68 grs. which is equal to 2.01 grs. of lime, or 0.67 gr. in an ounce, according to the proportions of Dr. Thomson* of 35.5 of lime in 100 parts of the oxalate.

c. To the clear solution from which the lime had been thrown down, I added ammonia, and as it produced no change I concluded that no sulphate of magnesia exists in the brine.

But as 2.01 grs. of lime will only take up 2.9 grs. of sulphuric acid, I infer that the remaining 4.47 grs. of acid must be combined with soda.

Recapitulation.

1. By Exp. A. it has been shewn that one ounce measure of the brine contains 64.7 grs. of muriatic acid, and as by Exp. B. *e.* it has been shewn that there is no muriate of lime, the whole of this muriatic acid must be in combination with soda, with the exception of the small quantity of muriate of magnesia found by Exp. B. *f. g.* Muriate of magnesia, according to Dr. Marcet,† contains 56.01 per cent. of acid, therefore deducting 0.18 gr. for the acid contained in the 0.32 gr. of muriate of magnesia obtained in Exp. B. from three ounces of the brine, or 0.06 for that contained in one ounce, there will remain 64.64 grs. of muriatic acid, which is equal to 140.52 grs. of muriate of soda in one ounce of the brine, according to the proportions of Dr. Marcet of 46 acid and 54 soda in 100 parts of salt.†

2. By experiment C. *b.* it has been shewn that three ounces of brine yielded 5.68 grs. of oxalate of lime, dried at 165°; and by

* Henry's Elements of Chemistry, sixth edition, vol. ii. page 141.

† Analysis of the Dead Sea, Phil. Trans. 1807.

Exp. C. *a.* and B. *e.* the lime has been shewn to be in combination with sulphuric acid: 5.68 grains of oxalate of lime, according to Dr. Henry,* are equal to 7.1 grs. of sulphate of lime, both salts being dried at 160°: there are therefore 2.37 grs. of sulphate of lime in one ounce of the brine.

3. From the several experiments made with the view of determining the amount and nature of the sulphates, it has been inferred that there are 4.47 grs. of sulphuric acid in combination with soda in three ounces of the brine, which, (according to the proportions of Kirwan of 25.52 acid, 18.48 soda, and 58 water,) are equal to 7.98 grs. of dry † sulphate of soda, or 2.66 in one ounce.

4. By Exp. B. it has been shewn that there are 0.32 gr. of muriate of magnesia in three ounces of the brine or 0.11 in one ounce.

Therefore the several salts contained in the ounce of the brine consist of

1. Muriate of soda . .	140.52 grs.	= 2248.32	grs. in a pint.
2. Sulphate of lime .	2.37 —	— 37.92	
3. Sulphate of soda .	2.65 —	— 42.40	
4. Muriate of magnesia.	0.11 —	— 1.76	
	145.65**	2330.40*	

* Phil. Trans. 1810.

† I calculate the sulphate of soda in the dry state, because in the estimate of the quantity of entire salt, in the brine (with which the gross amount of the several ingredients obtained separately will be compared) the residuum was dried in a heat sufficient to drive off the water from the sulphate of soda. To prove this, I exposed 152 grs. of the entire salt which had been dried in the same way, to a strong red heat in a platina crucible, and there was only a loss of about $\frac{3}{4}$ths of a grain, and that loss must have arisen from the water that would be separated from the sulphate of lime.

** This excess in the amount of salt obtained by the estimate of the several ingredients, may probably arise from the difficulty of drying the different salts to the precise point

Or Muriate of soda	. . .	96.48 per cent.
Sulphate of lime	. . .	1.63
Sulphate of soda	. . .	1.82
Muriate of magnesia	. .	0.07
		100.00

By Exp. B. *a.* it has been shewn that three ounces of the brine yielded by evaporation 431.86 grs. of entire salt, which is equal to 143.95 grs. in one ounce.

Before concluding this paper, I shall compare the results I have obtained, with the accounts of the Cheshire Brine Springs, given by Dr. Holland in his Agricultural Survey of that county, and subsequently by Dr. Henry in the Philosophical Transactions for 1810.

The densities of the different brines in Cheshire and at Droitwich are very nearly alike. In general, the former seem to contain rather a larger proportion of pure muriate of soda. The Droitwich brine is free from carbonate of lime, oxide of iron, and muriate of lime; all which are contained in that of Cheshire, though in very minute quantity. But the most remarkable difference between the two is, that the brine of Cheshire contains no sulphate of soda, which I have found in that of Droitwich, in the proportion of nearly 2 per cent.

implied in those experiments by which the proportions of their constituent parts have been determined.

* I have already stated, § 10. that there are 2289.75 grs. of entire salt in a pint of the brine from Walker's pit. In estimating that quantity, I made use of a *cubic inch* measure, whereas in the other case (by inadvertence) *an ounce* measure was employed. The difficulty of measuring the quantity very accurately in both cases is very great, and in a saturated solution, an imperceptible variation in *bulk* would become very sensible in weight.

I was disposed to doubt the accuracy of my experiments, until I found that Nicolas,* in his memoir "Sur les Salines des Departemens de la Meurthe, du Jura, du Doubs, & du Mont," Hassenfratz† in his memoir "Sur le Sel Marin, and Montigny‡ in his memoir "Sur les Salines de Franche Comté," state sulphate of soda as a constituent part of all the brine springs they examined. There is therefore no reason why this salt should not exist in the brine at Droitwich; especially as it is one so commonly met with in mineral waters.

It is foreign to the object of this paper to describe the process adopted in the manufacture of salt at Droitwich. It does not differ in any material respect from that employed in Cheshire, of which Dr. Holland has already laid before the public a very full account in his excellent work already alluded to.

* Annales de Chimie, vol. 20. † Annales de Chimie, vol. 11.
‡ Memoires de l'Academie des Sciences, 1762.

VI. *On the Veins of Cornwall.*

By WILLIAM PHILLIPS, Member of the Geological Society.

A Visit to the county of Cornwall in the year 1800, the inducements to which were the objects of mining and mineralogical inquiry, afforded me many opportunities of conversing with practical miners. The subject was new to me; and it was with considerable pleasure that I listened to the many striking and interesting facts detailed by men ever ready to communicate the information they possess, and whose minds, as repeated visits to the County have since confirmed to be their characteristic, are habitually disposed to industrious ingenuity. It may well be supposed that the foremost of these subjects was the nature and peculiarities of veins, or as they are technically termed, loads, or courses.* Having learned that the run, or direc-

* I have been at some pains to discover the original meaning of the term *lode*, or *load*, as the technical appellation of the east and west, or metalliferous veins of Cornwall. Borlase in his natural history of the county treats at page 146 of the *Fissure*, and the next chapter begins thus: ‘ From the Fissures let us proceed to that which they contain, whatever fills them, we call a lead;’ making a distinction between the fissure or vein and the substances it contains. He says in the same chapser ‘ where the load is barren, it may serve to *lead* us to what is rich;’ and in a note, concludes the term *lode* to be an old Anglo-Saxon word, meaning *lead;* thus *load*-stone, meaning *leading*-stone,’ and refers to Lye's Junius *ad verbum*. Without going so far back for an authority which nevertheless may be correct, I am induced to believe the term *lode*, though thus spelt by Borlase and Price, originally meant the burthen or *load* of the metalliferous vein. Carew, whose

tion of the regular metalliferous veins is about east and west, and that in some districts, the same vein is known actually to pass through several mines, it occurred to me, as being within possibility, that at least some veins might extend the whole length of the county; and that if the situations of such mines as were then working, or had lately been worked, were accurately described on a map, it might throw some light on the idea. With this view therefore, after visiting many of the mines, particularly those of the mining district of which Redruth may be said to be the centre, that object was accomplished by the assistance of some friends. The result by no means confirmed the idea in which it originated: for although it evinced that in the year 1800 there were about 120 mines in the county, either then working, or which had lately been worked, few of the east and west or metalliferous veins, from causes that will be explained in the following pages, have been explored, or even satisfactorily traced more than two or three miles. The map was however preserved merely with a view to private gratification; but several gentlemen, whose zeal for geological inquiry induced them to consider this attempt to shew the localities of mines as in some degree worthy of attention, urged my offering it to the notice of the Geological Society, accompanied by a memoir on the subject of the Veins of Cornwall.

The map not being of course adapted to the present state of the mines, nor even sufficiently exact in regard to their several localities at the time at which it was compiled, to meet the public eye, its publication is laid aside for the present, not however without expecta-

'survey' was published almost a century ago, not only so spells it, but at p. 8, in speaking of the effects of the flood on the rocks of the county, says it carried away so much of the '*load* as was contained therein.' Besides it is to be noticed, that the north and south veins, which are not metalliferous, are uniformly termed *courses*, making a clear technical distinction between unproductive and metalliferous veins.

tion of its being given in some future volume of the Transactions, in the most accurate and satisfactory manner.

But the ascertaining of the local and relative situations of mines, though of unquestionable interest to the geologist, can only be regarded as a link in the chain of inquiry. In order to render its value complete, it should be accompanied by a memoir, or rather a comprehensive history of each mine and of its connexion with those immediately contiguous to it on the same veins. But this could only be attained by years of unceasing and laborious inquiry on the spot. In the counting-houses of the most successful mines the only information ever committed to paper, in regard to the workings of the veins are the expenditure and income, together with a section of the vein from which the profit is reaped, without a single notice in regard to the tract of country through which it passes. Of the generality of unsuccessful mines, which form by far the greater proportion, all that is registered is the loss or expenditure; other information can only be obtained by a recourse to personal inquiries of the conductors or captains.

The following pages are principally intended to exhibit an outline of general facts relative to the veins of Cornwall, arranged under separate heads. In drawing up this sketch, such advantage has been taken of what has already been published on the subject as seemed consistent with the present object, carefully rejecting every thing doubtful, or hypothetical, and having in constant view the advantage of corroborating every assertion to the extent of my limited information, by a recourse to the peculiar circumstances of individual veins or mines. Though thus limited in its object and extent, it will I trust be found both consistent with its intention and accurate in its detail; nor will its service be trifling if, upon a subject so interesting, and on which little is known, it should be the means of inducing some of the numerous and well-informed men, who are immediately concerned in mines, to gratify the increasing interest which is felt on geological subjects, by giving to the world occasional details of the many curious facts that almost daily occur in practical mining.

Almost every mine of any considerable depth or extent, is deserving of the notice of the geologist, because each has its peculiarities:—for when two or more mines are on the same vein or veins, there is frequently but little else that is common to each; and even in the same mine, situated beneath a few superficial acres, there is often a strange variety in the dimension, contents, and direction of its veins, and in the country * through which these run.

Direction and Length of Veins.

It has already been remarked that the regular or metalliferous veins generally take the direction of about East and West; there are others both in the same and in different directions, most of which are very rarely found to produce any metallic substance; the nature and peculiarities of these will be noticed hereafter. The regular veins are almost uniformly of considerable length; some are known to extend two or three miles, having several mines on their run; and though the idea of their extending the whole length of the county may be judged to be hypothetical, it ought to be noticed that the most experienced miner never satisfactorily witnessed the termination of a vein either on the East or West. Many

* I have used the word *Country* in the sense in which it is employed by the miner, and shall hereafter so use it, conceiving it to be well adapted, if not better than any other I have been able to find, to convey the intended idea. If a miner be driving an adit North and South, or in any other direction than that of the Load, he says he is "driving through the country."

circumstances of disaster, and more particularly that of poverty, occur to prevent their extent from being known; but that there are instances of their appearing not to exceed a few fathoms in length, is evinced by the ground plans of Herland and Drannack mines, accompanying this paper. In reality however the veins of those mines did not terminate as represented on that plan, but continued both East and West, to an unknown extent, in strings so very small, as to be only just perceptible, and therefore not worth the attention of the miner, whose experience induces him to believe that when a vein diverges in metalliferous strings, however small, they would, if pursued, be found ultimately to increase in size, or to converge again, or to diverge to other veins, which are generally found to be, as it were, increased in size and value thereby. The East and West veins are sometimes found diverging from the straight line, even when apparently unaccompanied by any circumstance that might be assumed as the cause, but they generally return and resume their customary direction. In Huel Fanny, I think, the vein suddenly took a course to the South-East, in a few fathoms it was found to alter its course again, nearer East; afterwards it ran about East, and then elbowing again, it resumed its usual direction, nearly if not quite in a straight line. But circumstances of this kind are by no means common.

Underlie of Veins.

With the exception of those alluvial depositions of tin, found in vallies and low grounds in many parts of the county, and in the working of which the tin is separated from its accompanying earthy substances by means of passing a stream of water over it, whence they have been called *stream works*, neither copper nor tin is found in Cornwall in layers or beds. The veins, in which only they are found, have a downward direction, not perfectly perpendicular to the horizon, but inclining more or less to the North or South; this inclination is called the *underlie of the load*, which in some veins does not exceed a few inches in a fathom from the perpendicular, but in others is a fathom in a fathom, or even more.

When two metalliferous veins underlie in opposite directions, that is, one North and the other South, and meet underground, the result is not always favourable to the miner; for even though they might have been rich when separate, they generally are found to be poor at and after their junction. But when two lodes underlie in the same direction, and one of them quicker than the other, it is generally found that when the latter overtakes the former, they seem mutually to enrich each other.

Veins are not very frequently found to separate in the downward direction, so as to make branches forming distinct veins, having an opposite underlie. Instances of this however occurred in Tin Croft Mine, of which a Section is given.

Depth of Veins.

Not an instance, I believe, has occurred of a vein having been cut out in depth. When the working of a mine is relinquished, it is mostly either on account of its poverty, or the expense of sinking to a greater depth, being to a larger amount than the product. The mine called Crenver and Oatfield is 200 fathoms deep; Cook's Kitchen is 210; and Dolcoath 228 fathoms; these are the deepest mines in the county now at work.

Width of Veins.

The East and West, or metalliferous veins, are generally from one to three feet in width, but vary to 30 feet. In the old workings of Relistian mine for tin, there are chasms, both open to day* and underground, full 30 feet wide. A vein from one to three feet in width is preferred, because, though many instances of the contrary have occurred, it is found that the product is generally as good as in wider veins, on account of there being, for the most part, less admixture of foreign substances with the ore.

A vein sometimes varies in width in the same mine very materially, and is often found to increase in that respect in going down. One of the lodes in Huel Alfred ‡ varies from 9 to 24 feet: there is a peculiarity in its direction which is noticed in speaking of that description of irregular veins called Contres. As opposed however to the width of that vein, those of Herland and Drannack and Prince George mines, which are separated from Huel Alfred only by a brook and a cross vein, may be cited. There, instead of continuous veins of a somewhat irregular width, they are remarkably small, most of them varying only from 2 to 6 inches in the widest part, which was about the middle, and going away East and West in mere strings. A tin vein in Whealan Coates mine, not 3 inches wide, was very rich, and found to be worth working.

If in working on the course of a vein, or in sinking through the load, the country is found to assume a greater hardness in a very considerable degree, the vein generally becomes narrower.

* Ore is said to be discovered near the *day*, when it lies near the surface.

‡ *Huel* signifies a Mine, according to the Cornish-English Vocabulary of Borlase. It is commonly, though erroneously spelt, Wheal.

Denominations of Metalliferous Veins.

The substances which form the contents of the metalliferous veins differ very materially; nor are veins distinguished simply by the name of the ore for which they are wrought, as a Copper Load, or a Tin Load; but they have obtained various appellations, according to the nature of the substances found to predominate in them. For as the greater proportion of the contents of most of them, is neither the ore of copper nor that of tin, the miner in speaking of them, gives them the appellation which is technically descriptive of the vein-stones:—as a gossany, sparry, mundicky, peachy, flucany, scovan, caply, pryany, black jack, and a grouany Load.

Gossan is a friable ferruginous substance, consisting generally of clay, or of some siliceous matter of a loose texture, coated or tinged with iron, in various proportions, arising probably from the decomposition of pyrites; it varies in colour, from pale yellow to deep red, sometimes inclining to black. A Gossany Lode is more common than any other, and most promising both for tin and copper. Gossan has been plentifully found at small depths in many mines that produced considerable quantities of one or the other metals, both beneath as well as mingled with it; as of tin in Huel Sparnon and Pednandrae, and of copper in Huel Gorland, and in East and West Huel Virgin.

When the load or contents of a vein is termed *sparry*, this does not imply that it is of solid spar or quartz, but that quartz predominates. A vein in which this substance is considerably compact is very unpromising; and if at the same time the vein becomes narrower as it descends, it is generally relinquished as a hopeless undertaking; which was the case in Huel Gorland, as noticed in my memoir on the red oxide of copper.* A vein abounding in fluate of lime

* Geological Transactions, vol. 1.

is often termed a *sparry* load. Quartz is sometimes called hard spar by the Cornish miner, and fluate of lime, sugary spar.

If iron pyrites abound, the load is said to be *mundicky*, and when this occurs at a shallow level it is not always unpromising: even if it continue in depth, and be somewhat compact, particularly if mingled with portions of yellow copper ore, there are many instances of such veins proving rich beneath. No distinction is made by the miner between iron pyrites and arsenical pyrites. The latter is however rarely very abundant.

A vein that contains a great proportion of chlorite is termed a *peachy* load: it promises for tin rather than copper, which is rarely accompanied by chlorite. Tin was found in it, in Pednandrae, Polgooth, Relistian, Huel Unity, and in many other mines. I have specimens of the yellow copper ore in chlorite from Relistian and from the Wherry mine, the workings of which were under the sea in Mounts' Bay.

A vein is said to be *flucany* when either one or both its sides, or walls, are lined with a whitish or bluish clayey substance, or when this substance is interspersed through the vein itself. Flucan in some few instances has abounded so greatly, that it has been difficult to prevent its running in upon the miner in working the mine. This was the case in the early working of the productive copper mine called Huel Alfred, as is noticed in the annexed description of some of its veins.

When tin ore is intimately mingled with quartz and chlorite, the vein is termed a *scovan load*, which is of a dark brown or of a greenish hue, but not very hard, or compact. A load of this description rarely exceeds 12 or 14 inches in width, but it sometimes occurs in a vein the contents of which are not solid, thence by the miners termed a *sucked stone*. A load so circumstanced is often several feet wide.

A vein is termed a *caply load* when consisting of a hard, compact and unpromising substance, which seems principally to be quartz intermixt with minute portions of chlorite, giving a greenish, or brownish green tinge to the mass. Tin is often found in it, copper rarely. But if a branch of copper ore, or a gossan be found to take its course down the vein, it commonly makes a durable copper mine.

A vein is said to be a *pryany load*, when the tin or copper ore does not occur in a compact state, but when the stones containing either of them are found mixed loosely with other substances, such as gossan or flucan. *Pry* in the Cornish language signifies clay.

A vein that abounds in blende is called a *black jack load*, which is generally unpromising for tin, but is considered a good omen for copper. It is rarely found that blende continues to any considerable depth. It is also called mock-lead by miners.

Grouan * is the common technical term for granite, so that when a vein abounds in that substance, either in masses or blocks, or in a decomposed state, it is called a *grouany load*, which is rarely found except in a granite country. Grouan is more promising for tin than for copper; though veins containing the latter have often of late been found in the granitic districts of Cornwall, of which the western part of West Huel Virgin, Carharack, and Huel Damsel, all rich copper mines, are instances.

It must be remarked that veins generally take their names from the substances which abound but a little way below the surface. But, the circumstances of veins change so often, and their contents frequently participate so largely of the nature of the country they traverse, that the same appellation will not often hold for them in

* *Grouan* signifies Gravel, in the Cornish language, *Borlase.*—It seems therefore probable that Grouan, correctly speaking, is decomposed Granite.

depth. A satisfactory trial of their nature and value can rarely be made, without sinking 30, 40, or even 60 fathoms below the surface, and driving, at various depths, east and west on the " course of the load."

Symptoms in Veins.

In the whole range of the employments of man, there is not perhaps another in which experience and ingenuity are more often and completely baffled than in mining. Not unfrequently the appearances in a vein considered to be of the most promising kind, lead on the most experienced miners during the lapse of many years only to ultimate and immense loss; while on the other hand, from the product of veins, which by men of not less experience have been declared to promise no advantage, large profits have been reaped. The great copper mine called North Downs, in the working of which no less a sum than £90,000 was lost, may be considered as an instance of the first, and Huel Alfred, from which a greater sum has been gained, is an instance of the second. There is scarcely one symptom on which the miner most relies that has not occasionally deceived him. It may be curious however to add some of the symptoms in favour of which the miner is greatly prejudiced. There is no one more favorable in his estimation than a gossany load. I remember that of North Towan Mine was of this description, and of so great promise, that several of the most experienced practical miners did not hesitate to declare it superior, in that respect, to any other they had seen; and that, if compelled to venture all they possessed, in the working of any one vein, it should be that of North Towan; but, after much time and expense had been bestowed in trying it, it was found to be very poor, and was therefore abandoned.

The early discovery of iron pyrites and portions of yellow copper ore mingled with a large quantity of blende is considered a favorable omen for copper. Blende, as has already been noted, is by the miner called Black Jack; and 'Black Jack,' he says, 'rides a proud horse,' a phrase become proverbial, from blende being often found to lie above, in a vein rich in copper beneath. Vast quantities of it were found above the ore in the productive copper mine Huel Towan, as well as in that called North Bennar. The early discovery of lead is also considered a good symptom; very many tons of it were sold from Huel Alfred in the states of sulphuret and carbonate. Iron pyrites at a small depth is also considered a favorable symptom for copper in depth, as was proved among many others in the rich mines of Crenver and Huel Virgin; but when it proves solid, it has often discouraged the miner and induced him to abandon the vein. The cutting of a 'good course of water' is esteemed no unfavorable circumstance, especially if it be warm, and it is not uncommon to find water issuing from one part of a vein of a temperature sensibly higher than that in other parts of it. So greatly indeed does water abound in rich veins, that on extensive and deep mines are mostly seen two, three, and even four steam-engines, for the purpose of drawing it, the cylinders of which are from 30 to 66 inches in diameter. If a vein be particularly rich, it is considered to omen well for the parts of other veins immediately north and south of its riches; to express which the phrase of "ore against ore" has been adopted.

It would scarcely be correct to say that the early discovery of tin in a vein is a good promise for copper in depth, but it is certainly true that tin is frequently, if not mostly, found at a small depth in veins, afterwards proving rich in copper. Among many other instances of this that might be quoted, are the two deep and extensive copper mines called Huel Unity and Cook's Kitchen, both of which were, I believe, worked for tin at first, without any suspicion of their veins being rich in copper beneath it. In both the tin was soon exhausted; but it should be noticed as an uncommon circumstance, that in the latter mine, after working to the depth of 180 fathoms, first through tin and afterwards through copper, tin was found again, and has continued down to the present depth of the mine, which is about 210 fathoms from the surface. It ought however to be noticed that some parts of that portion of the load which principally contained copper ore, had been left, on the presumption of their not yielding ore of any sort; in the phrase of the miner they were considered as *deads*. Some of these have since been found to produce tin, which may consequently be said to have prevailed more or less from the surface to the bottom of the present working. A considerable proportion, if not the chief part of the copper ore of this mine, was the sulphuret.

Among the favorable symptoms to which the miner is attached there is still another, which ought not to be forgotten. There are some among them credulous enough to believe that they hear, while employed under ground, another pick at work, which is immediately referred to the agency of an invisible spirit, or what they term a piskey, or small man. This is esteemed an omen of the most favorable kind, and which induces the full belief of having nearly arrived at the desired object, the discovery of 'a good course of ore.' It seems as though the sound which the miner hears, may reasonably be accounted for by presuming him to be at work in the immediate nighbourhood of a cavity, or as he terms it, a voog, which returns the sound of the stroke of his own pick.

Discovery of Veins.

The discovery of metalliferous veins is effected in various ways. Amongst the foremost of these, Pryce places that of the Virgula Divinatoria; but, after a long account of the mode of cutting, tying and using the rod, interspersed with observations on the great difference existing in the discriminating faculties of constitutions and persons in its use, altogether rejects it, because 'Cornwall is so plentifully stored with tin and copper lodes, that some accident every week discovers to us a fresh vein,' and because 'a grain of metal attracts the rod as strongly as a pound,' for which reason 'it has been found to dip equally to a poor as to a rich lode.' These, it must be acknowledged, are substantial reasons for the neglect and disuse into which the rod has fallen. There are not however wanting even now, in Cornwall, some who maintain the value of it. I am acquainted with one person who has repeatedly declared to me that, while using it in his own shop in the town of Redruth, he discovered a vein which has since formed a part of the workings of Pednandrae mine for tin. On the other hand, an intimate friend well conversant with mining concerns was present in Somersetshire with some noblemen and gentlemen, the proprietors of land in that county, anxious for the discovery and working of veins supposed to run through their estates, when a person who professed the skilful use of the divining rod assured them he could effect their wish. During one of his attempts, my friend, as though by accident, took his station immediately facing the professor of the rod, who advanced with the rod dipping as he declared to the run of a vein; my friend retreated, and in his retreat made a circuit, which as he had in some degree caught the attention of the person holding the rod, was followed by him; and the pegs that were inserted in the places his feet had touched proved the circuit he had made. If a vein actually ran in that direction, it is certainly wholly different from that of any known vein. It is almost needless to add, that the discovery of the supposed veins as indicated by the means of the divining rod, was not attempted.

The ancient mode of *shoding* for tin-veins, consisted in tracing certain stones, of which tin formed a proportion considerable enough to excite attention, and found at or a little below the surface, to the vein from which they had been accidentally detached, so as to have passed in a sort of succession down the side of a hill. Another mode of seeking tin veins is by sinking pits through the superincumbent earth down to the solid rock, and driving a trench from one to another, north and south, so as to meet with every vein in the track through which it passed. This method, which is also esteemed to be very old, is called *costeening*.

The former of these methods for the discovery of tin veins is now rarely resorted to; but the second, as well as another which differs not much from it, that of working drifts across the country from north to south, is sometimes practised. Many tracts of the mining part of Cornwall are however so amply stored with veins in the direction of East and West, that there is little occasion to employ either of the above mentioned modes of discovery. There are comparatively but few mines which are known to have within their boundary only a single vein; in some there are 5, 6, or even 7. As the driving of an adit home to a vein is one of the first and most important tasks of the miner, he sometimes embraces the opportunity of so doing from a neighbouring valley along a cross course, or North and South vein, and for two reasons; the first, that the expense is less than if he were to drive through the solid country; the second, that he has at least a good chance of meeting with all the veins between the extremity of the adit and the vein to which he intends to drive it. Yet of this he is not altogether certain, for the east and west vein is sometimes so greatly disordered by the cross vein, as that it might wholly escape the notice of the miner; besides, cross veins often divide into branches, so that the miner runs the hazard of following the wrong branch, and thereby of missing altogether the metalliferous vein. But although the mode of discovering veins, by driving an adit along the run of a cross course is at once the cheapest and most expeditious method, it is not always practised, as the foresight of the experienced miner sometimes induces him rather to drive through the solid country than to hazard the chance of being obliged to draw the water of the country all around him, which he is aware the cross vein would prevent from troubling him on one side.

Accident often occasions the discovery of veins. That of the mine called Huel Maggot, or Velenoweth in the parish of Phillack, was first seen by workmen employed in digging a trench for the foundation of a garden wall in a valley. It there consisted of a rich gossan, which in the phrase of the miner was *very kindly*. On driving into the hill, a few fathoms on the 'course of the load,' it produced abundance of sulphat of lead in well defined crystals, sometimes accompanied by the sulphuret, and sometimes deposited on the gossan, and, a little deeper, copper ore in considerable quantity. Both were however soon exhausted, and the mine was abandoned. The run or course of an east and west vein may sometimes be traced on the surface, by loose fragments or portions of earthy or stony substances, having generally more or less of an ochreous tinge, but this, which is called the 'bryle of the load,' has rarely a regular separation from the country on each side of it. But in sinking a few fathoms below the surface, it assumes more determinate marks of being a fissure.

Contents of East and West or Metalliferous Veins.

The contents or load of the generality of veins, if at all attached to their sides, are for the most part easily separated. A dark ochreous crust occasionally covers one or both sides of the vein, technically called the *walls of the load*; and when these, or at least one of them, is regular and determinable, they are more encouraging to the miner than when rough and uneven. A thin coating of flucan is found on one, or occasionally on the other wall, or sometimes on both walls of a metalliferous vein, as described by pl. 6. fig. 4. but it is said that this coating or vein of flucan is most commonly found on that which, in regard to the underlie of the vein, may be called the upper wall.

It has been already noticed, in speaking of the denominations of metalliferous veins, that there is a great diversity in their loads or contents, and that the same vein exhibits so little uniformity in that respect, at different depths, as to assume various characters. Near the surface the load consists for the most part of a sort of ochreous rubble, probably the debris of the neighbouring country; beneath which, though rarely nearer grass than 20 or 30 fathoms, are found some metalliferous indications. These, if gossan be the prevailing substance, consist of the ores of tin or copper. But iron pyrites, blende, fluate of lime, quartz, and sometimes chlorite, or flucan, frequently prevail for many fathoms, occasionally mixed with portions of the country through which the vein passes, though frequently with but slight traces either of tin or copper. A vein is sometimes found to consist of little else than a bed of hard and unpromising iron pyrites, which occasions its being abandoned; in others are found the ores of tin or copper, sometimes both, intermingled with some, or even most of the foregoing substances; but if they occur together, the copper for the most part prevails to such an amount, as that all traces of tin are lost in depth. In some veins however they continue to be found, even to a considerable depth, though not often much intermingled but in separate bunches; this as has already been noted, was the case in Cook's Kitchen Mine; the neighbouring mine, Tin Croft, also furnished a somewhat similar instance, though not I believe in the same vein; but these must be considered as somewhat rare occurrences.

Tin is commonly found much nearer the surface than copper. When either is very near, especially if abundance, it is in the estimation of the miner an indication that it will not continue to a very considerable depth, of which Cornwall furnishes numerous instances. There is a tract of country situate about midway between Truro and Redruth on the north of the high road, in most of the mines of which, and amongst them the great mine called North Downs, the ore for the most part occurred near the surface, and was almost uniformly found to extend but to a small comparative depth.

Although there are veins in various parts of the country which have yielded copper in its pure state in considerable abundance, in masses interspersed through them, and but little intermingled with other substances, or even with the ores of copper, yet the most common state in which this metal is found is that called yellow copper ore. It is more continuous and lasting than any other. There are veins which yield only the grey sulphuret, but this rarely or never continues, being found only in bunches. It is sometimes mingled with the yellow ore. As a proof of the great difference in the value of the ores of veins, it may be noticed that there are many which seldom yield it of a greater price than £4 or £5 per ton. A few tons were lately sold from the United Mines at £100. The general average perhaps does not exceed about £7. 10s. or £8 per ton.

In few metalliferous veins does the ore prove so continuous, as after it has been taken away to leave a large hollow load. The intermediate spaces between the ore are mostly filled with what the miner terms *deads*, which consist of quartz, fluor, gossan, iron pyrites and other substances, as well as occasionally portions of the country through which the vein runs; but the walls of the vein are nevertheless generally determinable. The deads are not always a disadvantage to the miner, as they serve to keep apart the country on either side the vein; but for this purpose, when the vein has been left hollow by taking away a large body of ore, strong timbers are made use of; these are not however always found to be of strength sufficient to prevent the falling in of the cavity. An instance of this occurred in the copper mine called Huel Alfred; one of the veins of which was hollowed out for about 100 fathoms in depth, 80 fathoms in length at bottom, and 30 fathoms above, and varying in width from 9 to 24 feet. Notwithstanding great labour, skill and expense had been bestowed, and the most substantial timber employed in order to keep apart the walls of the vein, many thousands of tons came down in an instant; fortunately seventeen men who had been working in the very place on which the whole fell, had left it half an hour before the accident. The whole has been supported, and they are now working beneath it.

It has sometimes happened that in a large load, and where it is largest, the miner has suddenly arrived at a piece of dead ground in the middle of it, which in depth spreads wider so as to occupy nearly the whole of the vein, leaving on each side only a small connecting string of ore. This has been known to extend many fathoms in length and depth, and from its being narrow above and widening below, it has obtained from the miner the name of a horse. The phrase on meeting with it is, 'the load has taken horse.'

The riches of a mine have in many instances proved the cause of great speculation, and consequent disappointment to those concerned in the mines immediately contiguous east and west, and on the same vein or veins. This has been but too unfortunately verified in the instance of East Towan Mine, which joins Huel Towan on the east; in the latter, which has during the last 10 or 12 years, from one large and unusually continuous bunch of yellow copper ore (the discovery of which was the result of a search of at least 30 years at a greater expense) yielded a very large profit. There were 50 fathoms of good ore-ground in the vein at about 66 fathoms under the adit, which adit is 42 fathoms from the surface, or in the technical language of the miner, from grass. The bunch of copper ore continued to that depth from near the adit level, and as in length it extended east towards East Towan Mine, expectations were raised that the load in passing through that mine would prove equally rich. Great speculation and expense of course ensued; but in vain. For it was found that in several of the levels in Huel Towan, the ore ceased within a very few fathoms of East Towan Mine, and in some places as suddenly as if it had been cut away by a hatchet. This was not the effect of a cross vein, but purely one of those accidental circumstances to which copper loads are very liable. The ore of Huel Towan is of a remarkably bright yellow, and generally pretty compact, but not hard.

Adits.

When it has been determined to try a vein, one of the first objects of the miner is to bring home an adit to it. An adit is a water course, or rather an underground passage, about 6 feet high and 2½ wide, and is begun at the bottom of a neighbouring valley and driven up to the vein, for the purpose of draining it of water above their point of contact. In the event also of the mine having a steam engine upon it to raise the water from a still greater depth, it is not raised by the engine to the surface, but delivered into the adit. The general level of the mining-country east and west of Redruth is, according to Dr. Berger, from 350 to 450 feet above that of the sea, except where the granite overtops the schist, as in the instances of Carn-brae, Carn-math, and some few other hills, the summits of which are at a considerably greater elevation. This general level of the country is intersected by frequent vallies, which afford great advantages for the formation of adits, and consequently for the carrying away of the water from the mines. One adit frequently serves this purpose, for 2, 3 or more mines. Pryce, who published his work, entitled Mineralogia Cornubiensis, about 30 years ago, says p. 148, ' Though we seldom see an adit half a mile in length, there are 2 or 3 of three times that length, these are the longest I know of.' But since his time, one has been driven through a considerable tract of country at the lowest possible depth, as its mouth or extremity is nearly on a level with the water in one of the creeks of Falmouth harbour, into which it empties ; and being below all other adits in that neighbourhood, it is called the deep adit. It does not run in one course, either direct or circuitous, the whole of its way ; but taking into calculation its various branchings in and through the numerous mines (those of Gwennap) which it relieves of their water, it may be said to be about 24 miles in length.

Taking into consideration the purpose of an adit, it might be presumed that it is wrought on an inclined plane from the place at which it joins the vein to the extremity in the valley. This may perhaps be the case with some, but the practice is not uniform. By making them on an inclined plane, a freer current would be given to the water, yet much of their benefit would be lost, even although their declination were not to exceed one inch in a fathom. For, in supposing this plan to have been pursued in the driving of the deep adit above mentioned, which, from its extremity to North Downs mine, is about four miles or 3520 fathoms long, it will be obvious that if a declination of one inch in a fathom be allowed, the elevation of the adit at North Downs mine would be about 300 feet above its extremity; an elevation nearly if not quite equal to that of the surface of the mine. If therefore in the driving of an adit any allowance be made for the current of water it may be presumed that the interest of the miner will induce him to make it as small as possible.

Country.

Veins containing copper, as well as those containing tin are found both in granite and in schist, though until within the last 50 years, it was esteemed in Cornwall a hopeless expectation to find a vein containing copper in the former of these rocks. Experience has however in many instances, in the parishes of Redruth and Gwennap, as well as in some others, proved that veins of copper ore are found in granite. In both of those parishes granite and schist have in some mines been found to alternate; this alternation has not, as I conceive arisen from their stratification, but from the casual unevenness of the first being supplied by a deposition of the second. It has, I believe, been but rarely noticed that the course of a vein has been along their junction; but some instances of this have certainly occurred ; and I was informed by Capt. William Davey, of Redruth, one of the most skilful and intelligent practical miners of the present day, and who was the principal manager of Huel Gorland mine, that for some fathoms both in length and depth one wall of one of its veins was of granite and the other of schist ; another instance is mentioned in the annexed notice of the accompanying section of Tin Croft mine.

The alterations in the country from schist to granite and back again to schist, are very frequent in some of the mining districts of Cornwall, so that it is impossible in a word to say in which some of the mines are situated, but I suspect this to be principally the case with those mines that are at the foot, or in the immediate neighbourhood of granite hills. I have not noticed any instances of the junction of these two substances in which the granite has not shewn a tendency to decomposition : it is sometimes separated from the schist by a slight ferruginous seam.

It will of course be understood that great variations in the texture and hardness both of granite and schist are observable. Of the former there seems every possible difference in hardness between the decomposed granite of Tol Carn mine, which, as well as that of several others, it was impossible to keep apart without lining the adit or the level with boards close to each other, both above and on each side, and the compact and fine grained granite, of which quartz forms a principal ingredient, and which in hardness is almost equal to porphyry. Of the great difference in the hardness of schist, I shall notice one instance in Huel Alfred ; in the sinking of two shafts in that mine, not much exceeding the distance of 50 fathoms from each other, the pay to the miner was in one instance £55 per fathom, but in the other only £5.

These frequent variations in the country through which the miner is under the necessity of passing in the usual course of his occupation in the sinking of shafts and driving of levels and adits, often prove the occasions of great hindrance and loss. There is a narrow channel of a remarkably fine grained substance consisting of compact felspar and chlorite, running in the direction of east and west, a little north-west of Redruth, which is so exceedingly hard as to have obtained the technical name of Ire-stone or Iron-stone. It was met with in driving an adit towards a mine, the Old Pool, I believe, and it has often been told me, that it was so remarkably compact in one place as immediately to turn the point or edge of every tool, so that it was found impossible to drive a hole deep enough to employ the blast by gun-powder: the miner was compelled little by little to pick through that part of it, in doing which the seat-board was not once moved forward during the space of 12 months.

The schist of Cornwall varies much in colour as well as in hardness. It passes from lightish grey through the shades of slate colour to that inclining to a reddish hue, which is considered to be promising as to the occurrence of tin. But that which is esteemed the most kindly both for copper and tin, as well as the least expensive in the working, is of a light grey colour inclining to slate. This kind of schist is easily broken, and may be left without much support, and is therefore what the miner terms *feasible ground*, but it often passes in depth into a far more compact kind, of a dark colour, inclining to blue.

Cross or North and South Veins.

It has already been noticed that there are veins in Cornwall, which as they are found almost uniformly to traverse the east and west or metalliferous veins* in the direction nearly of north and south, are technically termed *Cross Courses.* They rarely produce copper or tin, or any other metallic substance. They vary from half an inch to a few feet in width: the underlie of some is east, of others west; others again have little or no perceptible underlie, but are nearly perpendicular to the horizon. In some tracts of the mining country they are of very frequent occurrence, as the accompanying ground plan of Herland mine will evince.

Cross Courses, or north and south veins, may be subdivided into 1st. a Quartzose vein, to which the general term of *Cross Course* has been given—2nd. a vein containing a soft marly or clayey substance of a bluish or whitish appearance, called a *Flucan*; and 3d, a vein containing a substance of an ochreous and friable nature and of a yellow colour, called by the miner a *Cross Gossan.* Every cross course or cross gossan is however accompanied by a flucan. In speaking of these veins the miner sometimes gives them their technical appellations, but he is more habitually disposed, whatever the substances of these veins may be, to call them by the familiar term of cross courses.

The principal advantage derived from the north and south veins is that, when their substance is flucan, or even when a continuous vein of flucan, however thin, accompanies the quartz or gossan, they prevent the water of the neighbouring country from troubling a mine, and they are sometimes left to perform that useful office, as was the case between Huel Sparnon and East Huel Sparnon, near Redruth. But their disadvantages are numerous; for although the regular metalliferous veins are occasionally found to be but little or not at all disturbed by the passing of the substance of the cross vein through them, except by the mere division of the load, it more often happens

* A rare exception (the only one I am acquainted with) has been found in the mine called Huel Alfred; a description of some of its veins is annexed.

that it is as it were broken into small strings or branches. By a careful examination of the nature and direction of these, the miner is indeed sometimes enabled to find pretty readily that part of the load which is on the other side of the cross vein, but he is often baffled. Instances have occurred in which the load has, as it were, been turned by the cross vein, so as to form what the miners term an elbow.

Not only does the substance, whatever it may be, of the cross vein, almost uniformly pass through that of the metalliferous vein, but it is often found so to interrupt its course, as, in the phrase of the miner, to *heave* that part of the vein, east or west of it, a few inches, or even many fathoms north or south : and as the metalliferous vein is frequently found to be poor on one side of the cross vein, though rich on the other, its occurrence sometimes not only baffles the skill of the most experienced miners, but also causes much loss and vexation, as the annexed account of some peculiarities in the veins of Tol Carn, Huel Jewel, and Huel Damsel mines, will shew.

Though the cross courses, or north and south veins, are rarely found to be metalliferous, or even to yield any of the ore of the east and west veins through which they pass, a general exception was found to exist in those of the great tin mine near St. Austle, called Polgooth, in which, I believe, they universally produced tin. Two of the cross veins in Herland and Drannack mines yielded silver—one of them very sparingly, in the other it was accompanied by other metallic substances : the quantity of silver amounted in value to 8 or £9000. Pryce says* that cobalt has been found in veins of this description, that others have been worked for lead, and † that the direction of antimonial veins is

* Min. Cornub. p. 50. † Ibid. p. 50.

mostly north and south, but that he had not known 'any producing that mineral of more than fourteen fathoms deep.' The mine called Huel Boys, which formerly produced the triple sulphuret, is now worked for antimony, which occurs in bunches of various dimensions in a vein, the direction of which is nearly north and south, and of about five feet in width. The antimony is accompanied by blende only, and is not now found in a state of crystallization. The country through which the vein runs is schist.

Slide.

Veins, not of a metalliferous kind, but which contain gossan, or flucan, are sometimes found running north and south, with an east or west underlie, generally very quick, one of which will be noticed on a reference to the section of the *Manor Old Vein.* Veins of this description are also found in the direction of the metalliferous or east and west veins, having an underlie north or south. But whether their direction be east and west, or north and south, and whatever their underlie, they are frequently the cause of much expense and vexation to the miner. When the underlie of this species of vein is in the same direction as that of the metalliferous vein, but quicker, so as to overtake it in depth, the latter is generally divided by the former, and, as it were, removed from its regular course. The load of the metalliferous vein is also sometimes altered in respect to its value, above or below its section, and the space between *a* and *b*, Pl. 6. fig. 2. as it regards the load, is as it were lost. This kind of vein, from its direction, has obtained the name of *Slide*, and the phrase is, 'the load is cut out by a slide;' its flucan or gossan, generally traverses that of the north and south, as well as the east and west veins.

Heave.

But when the underlie of this species of vein is in opposition to that of the metalliferous vein, the effect of it is immediately the *reverse* of that of the Slide, and is called the *Heave.* Pryce has noticed a remarkable instance of this which occurred in the Goon Laz and Pink tin mines, in the parish of St. Agness. The tin load underlaid north, the gossan vein south. (Pl. 7. fig. 7.) At 62 fathoms in depth, it separated the tin load at *a*, *heaving* the other part of it up to *b*, 22 fathoms in perpendicular height, and 19 fathoms horizontally north. Another gossan vein afterwards cut the tin load at *c*, heaving it up to *d*. The tin load then resumed its course, until another gossan vein separated it at *e*, heaving it up to *f*.

It will be observed that the effect of the heave is that of affording a greater portion of the tin load at a given depth from the surface, than would have been the case had the vein pursued its regular downward direction. But this is not always a compensation to the miner; for the vexation and expense accruing to him in searching for the tin vein generally exceed any advantage to be gained by the heave. It was, I believe, principally the effect of a heave that baffled the skill and experience of the most eminent practical miners in Huel Peever; in which mine they were, during about 40 years, in search of the load, and which was at length discovered. Perhaps the history of that mine, and of the long and vexatious search, occasioned by the loss of the vein, would prove the most satisfactory evidence that can be obtained of the strange phenomena occasioned by the heave; and I have the satisfaction of knowing that it is the intention of a gentleman, who has nearly completed an account of it, to present it to the Geological Society.

In describing that effect produced by the interruption of one vein by another, called the heave, it ought to be noticed that a copper vein going down with a quicker underlie than a tin vein, always passes through it, and sometimes interrupts its regular course. And if the underlie of the copper vein be south, and that of the tin vein north, or vice versa, the copper vein continues its course, but interrupts that of the tin vein, heaving it out of its first direction; and although Pryce has merely given the appellation of 'Gossan' to those veins that heaved the tin veins, as just noticed, it seems to me probable that these 'Gossans' were veins containing copper, which is rendered the more so, as the term 'Gossan' is frequently given to a copper vein, merely from its being the prevailing substance. The heave of a tin by a copper vein was, I believe, one of the remarkable and complicated disasters which befel the veins in Huel Peever.

Feeder.

A small *metalliferons vein or string* is sometimes found to take the same course as the east and west vein, (Pl. 6. fig. 3.) When its underlie is so much quicker than that of the latter, as to overtake it in going down, the metalliferous vein is generally found to increase in size, not merely in the proportion of the addition of the lesser vein, but very much more, so as to make a great body of ore, called by the miner a *gulph of ore* at their junction. This species of vein is therefore termed a *Feeder.*

Leader.

While working in the course of a load, small metalliferous branches or strings are occasionally observed to strike into the vein from the north or south, which, it seems probable, have before diverged from the same, or some neighbouring vein, (Pl. 6. fig. 5.) It is not certain that copper veins are equally subject to this circumstance as are those of tin. In Polgooth and Carnmeal tin mines, their effect was the sudden enlargement of the load to what is termed a *floor of tin*, twelve feet or more in breadth, but without the determinate walls usually observable in regular veins. A floor of tin rarely continues for any considerable length or depth, and the load is generally soon found to resume its usual size and appearance. From the common effect of this kind of branch or string, it is generally known by the term *leader*.

The Contre.

There occurs still another species of vein, of which the course or direction is generally about north-east and south-west, and which therefore is oblique in respect to all other veins; from this circumstance I presume it to have obtained the name of *Contre* or *Caunter*. They are mostly, if not always, metalliferous; several instances have occurred of their being remarkably rich. Two instances will be noticed in the annexed descriptions of Huel Alfred and Herland mines, in both of which they were very productive of copper ore.

It may here be noticed, that in the former of those mines, the regular or east and west vein was disturbed by the contre, and for some distance totally disappeared on the west. In the latter, both the load of the regular vein and that of the contre were enlarged, and became more productive by uniting.

Elvan.

Elvan is one of the three grand distinctions made in regard to rocks by the Cornish miner. Whatever is not grouan (granite) or kill as (schist), is of course with him elvan. So that, in fact, it is extremely difficult to say what it is or even what it is not, with the exception of granite and schist. The substance to which it is most commonly applied occurs frequently in Cornwall, not as forming tracts of country, but interposed between the schist, in what is termed by the miner a channel. I know of no instance of its thus occurring in granite. The situation of these channels is not horizontal: they generally dip at various angles with the horizon, and in various directions. The colour of elvan is bluish-grey, or yellowish. It does not always disturb the contents of the metalliferous vein, which generally continues through it, though the load is mostly narrower than when in the schist; but it sometimes has the effect of dividing it into small branches. By the accompanying section of Pleasure, Fancy, and North Herland veins, Pl. 8. fig. 10. it will be seen that a large channel of elvan took a course opposed, though not opposite, to that of the metalliferous vein, and that two other channels took similar directions by the section of the Manor Old Vein, fig. 11. The examination of some specimens induced me to consider the elvan of those mines to consist of crystals of quartz and felspar imbedded in compact felspar; in one specimen, the latter was intermixed with compact quartz.

In the preceding pages I have aimed at giving a mere general *outline of facts*, which, considering the imperfect state of geology, seems to be rendering better service to science than could be derived from a feeble attempt to raise upon their basis any theory explanatory of their occurrence. Nor indeed is the knowledge of insulated facts sufficient to authorize such an attempt on this important and difficult subject, comprehending operations on so grand a scale, of a date so remote, and throughout a country so greatly diversified. Before such an explanation can be satisfactorily accomplished, we have much to explore and to learn. The task seems to require a combination of talent and of information, which but rarely exists. But that a faithful detail of mining facts may contribute to assist the geologist in his inquiries, can no more be doubted, than that the science of mineralogy is absolutely essential to assist him in his researches.

It is to be regretted that the practical miner, in every part of England, is almost wholly ignorant of the principles and facts of mineralogy and geology. Even the conductors of the mines, termed captains, are men generally of little or no education, who have risen to that station by a superior attention to their art, in which they have been incessantly occupied from the early age of five or six years. A century ago among the miners of Cornwall, whatever was not tin was heedlessly thrown aside; and within that period, on the discovery of copper ore beneath the tin, it was no uncommon observation, that the 'ore came in and spoilt it.' It is an undoubted fact that many roads in the county were mended with copper ore. The discovery of the native silver in Herland mine would have passed unnoticed, but for the vibrations of some capillary portions having accidentally attracted the notice of a workman; and it is confidently believed that much of that precious metal has been thrown away on the neglected heaps of that mine. Even now, whatever is not manifestly tin or copper, or is not suspected of yielding those metals, is paid little attention to ; and the practical miner sees no value in the inquiry into the run of veins, the nature of the country they traverse, their contents, or uniformity, further than relates in his own estimation to the immediate benefit of his occupation ; and he smiles at the nice discriminations of the mineralogist. If an inquiry into the phenomena of veins be made of him, he refers, by one short cut, to the universal deluge.

The total ignorance of almost every thing relating to the sciences of geology and mineralogy, and above all of chemistry, in the conductors of mines, and their agents, is not only matter of regret, but it can scarcely be doubted, is also the cause of much loss to the adventurers in mines, to the lords of the soil, and to the buyers of the ore. If a spirit of inquiry had existed, which some knowledge of these sciences could not have failed to produce, much cobalt would not have been thrown away on the heaps of Dolcoath and some other mines, nor would bismuth in Huel Sparnon have been mistaken for cobalt, nor would the roads have been mended with copper ore, nor would the ponderous ore, which contained silver in Herland mine, have been left to the chance that discovered its value, nor would many miners, in opposition to all the known principles and properties of mineral bodies believe, even to this day, in the regeneration of metals.* While in France, and in Germany, there

* "Whether tin doth grow again, and fill up places which have been formerly wrought away, or whether it only separateth itself from the consumed offal, hath been much controverted, and is not to this day decided." And "whether—dead lodes—that have not one grain of tin in them—may not hereafter be impregnated, matured, and prove a future supply to the country, when the present lodes are exhausted, I think well deserves our highest consideration." Notes to Carew's Survey of Cornwall, edit. 1811, by Tonkin, edited by Lord de Dunstanville. It must be confessed that these inquiries still prevail amongst practical miners.

are national institutions for the education of those intended to conduct the working of mines, in the three important branches of science before alluded to, and which are so intimately connected with their occupation, in this country all is left to accident, and the rich gifts which nature has bestowed upon us, are consequently often neglected, or lavishly thrown away.

The ores of copper, as sold at the mine, though some of them are richer, do not in most instances contain more than one-twelfth of copper, frequently not one-fifteenth, some of them not one-twentieth. The accompanying substances are a heterogeneous mixture of earths and metals, amongst which arseniates of various kinds often bear a considerable proportion. It needs not to be insisted upon that much attention ought to be given to free copper from arsenic, which is so very liable to render it brittle. When a pound or two of the ore is given to the sample-trier, as a fair sample of 50 or 100 tons, his report is but too often grounded on the weight of the *prill* he has obtained from a given quantity of the ore, without reference to the substances with which it may be alloyed, which indeed his skill does not enable him to detect. When the ore is taken from the mine, it is for the most part deposited, not that of each mine separately, but mixed with that of many others, without regard to the great difference that must of course exist in the ore of veins, circumstanced so variously as are those of Cornwall.* And strange as it may seem, it is notwithstanding true, that even the interest of the buyer seldom tempts him to swerve from

* In reply to this observation, it has been said that the ores of some mines are found to smelt more easily when mingled with those of certain other mines than alone. This will not perhaps be doubted. All that is now contended against is, the common practice of mixing indiscriminately ores of copper of any, or rather of every description.

the hacknied practice of his predecessors, in making purchases to an enormous amount on the reports of those whose skill only extends to the extracting of the heaviest prill, without possessing a knowledge of chemistry sufficient to enable them to discover of what it is compounded.

Enough has been said in the preceding pages of the uncertainties attending the pursuit of the miner, to amount to evidence that skill and ingenuity are often exerted in vain:—all they can do is to determine on, and put in practice the speediest and most effectual methods of ascertaining the value of a vein, at the least expense. When assisted by the best experience, they are utterly unable to form a conjecture, grounded on reasonable certainty, that the great expenses attending the trial of a vein will be repaid. If indeed the reverse of this were the case, there would not be as there now are, so many skilful captains of mines who have lost money by their adventures. If experience avails so little, theory cannot be expected to avail any thing; and it may fairly be doubted whether all that science could bestow on the practical miner, would, in this branch of his occupation, be found to be of the slightest advantage.

The habits of the miner are those of industry and perseverance, which often tempt him to exploits that excite astonishment at his venturous hardihood. The very idea of a descent beneath the surface of the earth has something in it of the terrible, at which those shudder who are unacquainted with practical mining. But such is the force of habit, that rarely does any other employment tempt a miner to forsake his own. The occasional perils of his occupation are scarcely noticed, or if noticed are soon forgotten. He walks often in the middle of the night, and in all weathers, two or three or more miles to the mine, undresses, and puts on his underground clothes, and with his tools slung over his shoulder, descends by ladders a depth of 1000 or 1200 feet, assisted by the light of a small candle, and works in the bottom of the mine six or eight hours, amidst the noise of the working of the pumps in drawing the water, with as much alacrity, and with as little sense of danger, as he would feel amidst his ordinary occupations above ground. We should be inclined to feel pity for the wretch who, as an atonement for his crimes, should be compelled to undergo what the Cornish miner voluntarily undertakes for a small pittance, and that even of an uncertain amount. 'The mine of Huel Cock, in the parish of St. Just, is wrought eighty fathoms in length under the sea, below low water mark; and the sea in some places is but three fathoms over the back of the workings, insomuch that the tinners underneath hear the break, flux, ebb, and reflux of every wave, which, upon the beach overhead, may be said to have had the run of the Atlantic ocean for many hundred leagues; and consequently are amazingly powerful and boisterous. They also hear the rumbling noise of every nodule and fragment of rock, which are continually rolling upon the submarine stratum; which altogether make a kind of thundering roar that would surprise and fearfully engage the attention of the curious stranger. Add to this, that several parts of the load which were richer than others, have been very indiscreetly hulked and worked within four feet of the sea; whereby in violent stormy weather the noise overhead has been so tremendous that the workmen have many times deserted their labour, under the greatest fear lest the sea might break in upon them.'

The account of Huel Cock above cited, is extracted from the Mineralogia Cornubiensis of Pryce, page 21. I have made some use of the mining information contained in that work, which, though it is often confused, and sometimes scarcely intelligible, is, apart from its reasonings and its philosophy, a valuable production. I have not thought it necessary to acknowledge my obligations to it in every particular instance ; nor, on the other hand, have I been willing to quote its authority, without verifying it by an appeal to some of my numerous friends among practical miners.

As an appendix, it seemed to me that some account of the veins of certain mines, remarkable either for their peculiarities or some striking geological fact, might therefore be an acceptable addition to the geologist, as well as in corroboration of what has preceded. I have however to express my regret that these relations are imperfect, inasmuch as little is said on the subject of the *countries* in which these mines lie. For as the information on that head could only be obtained from the practical miner ; and as he notices the country merely as respects the ease or difficulty with which his operations are carried forward, or at most no further than regards his three grand distinctions of grouan, killas, and elvan, little or nothing satisfactory could be obtained, on that important part of their history.

Ground Plan of Herland and Drannack and Prince George Copper Mines.

Pl. 8. fig. 9.

Herland and Drannack mines are situated in a hill that rises suddenly on the west for some distance, but which is afterwards nearly on a level for about half a mile, the highest ground being about the center of that vein termed the Manor Old Load, having a gradual fall to the south of the middle mine. The country is schist, but in some places so hard as to require the blast by gun-powder.

The general direction of the metalliferous veins is a little from the north of the east to the south of the west, and of the north and south veins or Cross Courses, a little from the west of the north to the east of the south.

Herland and Drannack and Prince George mines, and that called Huel Alfred, a description of some peculiarities in which is annexed, claim peculiar attention, as well on account of their being in immediate contact with each other, as because their situation in a schistose country, seems almost the only circumstance decidedly common to both. In almost every thing that respects their veins, it would perhaps be difficult to point out two mines more completely at variance, except that in each there occurs one of that denomination which is termed a contre.

Most of the east and west or metalliferous veins of Herland and Drannack mines varied from 2 to 6 *inches* in width, and whenever found to exceed the latter size, it proved an indication that they were about to diminish, and in the language of the miner, to pass away in the run of some fathoms in mere strings—a circumstance of extremely rare occurrence in the veins of Cornwall: they were consequently abandoned, because they no longer paid the expense of pursuing them east or west. It may well be supposed that considering the narrowness of these veins they were extremely rich; in fact they were so rich that it was frequently the practice of the miner, after taking away one side of the vein, to spread canvas to receive the load. That vein called the Manor Old Load exceeded the rest in width, being in the largest parts from one foot to one foot and a half in width, and the ore was occasionally found in floors of two or three feet wide, a circumstance more common in tin loads than in those of copper.

The direction of the contre is somewhat to the north of the west and south of the east: it produced a considerable quantity of copper ore, and varied from one to three feet in width. Near the surface great quantities of blende and iron pyrites were found in it. Wherever it intersected the east and west veins, their contents formed together one load at the junction for about eight fathoms in length and three or four in width. That part of the contre west of the cross vein called the Privateer Flucan was heaved by it northwards two or three fathoms, and the substances of both were mingled together. By Harvie's cross course it was heaved eight fathoms, and the substance of the cross course between the divided parts of the contre was found to be nearly twice its usual size, and consisted not of quartz only but of quartz mingled with iron pyrites, blende and copper ore, so that both the cross course and the contre in part lost their peculiar characters. The contre continued both N.W. and S. E. beyond its working, but was poor.

The substances of the numerous north and south veins or cross courses of these mines were quartz or flucan, or both. By the ground plan some variations will be observed in their directions, as being more or less to the west of north and south of east: it will also be seen that their general effect is to alter the course of the veins they traverse, by heaving, in the phrase of the miner, the western parts of them higher north, but with some exception, for the reverse was the fact in respect to those parts of the Manor Old Load and Middle Mine Load traversed by Chambers's Flucan and the Great Cross Course.

The discovery of silver in one of the north and south veins of these mines has already been made known by the publication of Mr. Hitchins's paper on that subject in the Philosophical Transactions. It may however not be amiss to take some notice of that peculiar circumstance. It was found in that part of Convocation

Cross Course which traversed the Manor Old Load, and was first noticed at about 116 fathoms from the surface: the Cross Course was at that place about $2\frac{1}{2}$ feet wide, but was narrower above, and consisted of quartz accompanied by a continuous flucan, which also was found with the silver. For some fathoms in depth after the first discovery of the silver, the Cross Course consisted for about 8 or 9 feet, and in some places for 3 fathoms, north and south of its junction with the Manor Old Load, of silver mingled with sulphuret of lead, iron pyrites, bismuth, cobalt, wolfram, &c. and these substances continued to abound and to traverse the copper load so long as it was rich while in contact with the cross vein.

It was noticed in the paper of Mr. Hitchins above alluded to, that the Rusty Cross Course, next on the east to Convocation Cross Course, also produced some silver, although not in sufficient quantity to pay the expenses of procuring it. This cross course consisted of quartz accompanied by a vein of flucan, sometimes on one side of it and sometimes on the other, together with iron pyrites occasionally.

The extent north and south of the channel of porphyry, or, to use the miners term, of elvan, which forms so conspicuous a feature in the section of Pleasure, Fancy and North Herland veins, is not known. Its effect in compressing the east and west veins is worthy of attention, and is noted on the ground plan, which, together with the accompanying sections are given from original documents now in my possession.

Section of Pleasure, Fancy, and North Herland Copper Mines.

Pl. 8. fig. 10.

The mines united under the name of Herland and Drannack were formerly worked separately, but were united on account of the drawing of the water being performed by the engines on Herland mine, and the name Drannack was added to Herland because two of the Mines (Fancy and North Herland) united with it were situated in a tenement of that name. This section therefore is that of the workings of the veins designated on the ground plan by the names of Pleasure, Fancy, and North Herland, north, middle and south branches. It is on the course of those veins, and supposes the country on the south side of them to be taken away, and of course in looking at this section we look north.

The shafts and levels which constituted the workings of these mines are not laid down, because they were not completed on the original, and even had they been so the present object can be as well accomplished without them. This section, together with the accompanying section of Herland mine, exhibits several striking geological facts.

By this section the underlie of the several north and south veins, or cross courses and flucans, which intersected the mines, will be observed.

It will also be seen that, to use the miners language, a large channel of elvan took its course with a very quick underlie towards the west: near the surface it was about 15 fathoms thick, but diminished gradually in depth. Its precise direction or extent on the surface towards the north and south was not ascertained. From some specimens of this channel in my possession, and of that passing through Herland mine, they appear to consist of crystals of quartz and felspar imbedded in compact felspar, which in one or two instances is mingled with compact quartz.

It merits particular notice that the substance of each cross course (viz. quartz) uniformly traversed the channel of elvan, but, while in it was much smaller and more compact than when in the schist.

That of the flucans, which consisted, when in the schist, of two veins of flucan or soft marl with portions of schist between them, were while in the elvan very much smaller, and their substance appeared to be either a mere seam of flucan, or was of a sandy nature resembling pulverized porphyry.

The metalliferous veins likewise passed through the channel of porphyry, which had no other effect upon them than that of diminishing the load in size; it therefore appeared to be richer.

The north and south vein, called Convocation Cross Course, was not found to produce any silver in this mine.

Section of the Manor Old Vein.

Pl. 8. fig. 11.

This section is on the course of the vein called the Manor Old Vein, on the ground plan of Herland and Drannack mines. It was originally worked as a separate mine, under the name of Herland. Its greatest depth was about 150 fathoms from the surface.

The several cross courses and flucans correspond with those in the ground plan. Halfpenny Little Flucan and Chambers's Flucan, were nearly, if not quite, perpendicular to the horizon; the underlie of the others will be seen. It will be observed on consulting the ground plan, that Williams's or Penberthie's flucan traversed the veins both of this mine and that of Pleasure, Fancy, and North Herland mines. North and South veins generally take the name of the shaft they most nearly approach. The flucan in this mine was nearest to a shaft called Williams's, and therefore obtained the name of Williams's flucan. In the other, it approached nearest to Penberthie's shaft, and was therefore called Penberthie's flucan. Both names are therefore given on the ground plan.

It was in this mine, as has been already noticed, that silver was discovered in Convocation Cross Course, as well as a very small quantity in Rusty Cross Course.

Two channels of porphyry also occurred in this mine; their effect on the N. and S. and E. and W. veins was similar to that produced by a channel of the same description in Pleasure, Fancy, and North Herland mine; their underlie and thickness are also about the same.

The underlie of the *Slide* is in the same direction as that of the channel of porphyry, but not so quick. Its substance was flucan of three or four inches in thickness; it passed through the cross courses and flucans. It also traversed the metalliferous vein, the course of which it interrupted, and heaved about fifteen inches, but whether to the north or south I know not. The load of the metalliferous vein was found to be richest a fathom or two along the run of the slide, both above and beneath it.

Transverse or North and South Section of Tin Croft Mine.

Pl. 7. fig. 8.

Tin Croft mine has been worked many years; and has yielded large profit both to the lord of the soil and to the adventurers. It was first worked for tin, principally, I believe, if not wholly, on the two most northerly veins. The country in which the mine is situate is for the most part schistose, but some remarkable alternations of schist and granite were discovered while working the two veins on the south, the probable cause of which appears to be this, that as these veins run parallel with and at the foot of the hill called Carn-brae, which is wholly of granite, the irregularities in the granite were supplied by a deposition of the schist. In no other part of the mine does granite appear, except that in following down two of the veins, as is noted on the accompanying section, they were found to traverse a mass of it at about 73 fathoms from the surface, above and beneath which schist only was observed.

The veins of this mine are worthy of attention in regard to their number, underlie, dimensions, and contents. In number they are seven; the other two may rather be called off-sets from a vein than veins. If however they be considered as veins, there are in this mine five of copper, three of tin, and one of tin and copper, in about a furlong and half of country from north to south. The general irregularities of their underlie, both individual and regarding each other, are very remarkable: only the Old Tin vein and Bodilly's vein proceed in a straight line, and it will be noticed that the New Tin vein proceeds in five directions, the second more inclining to the perpendicular than the first, the third more than the second, and so on. The South vein varies in width from one to six feet, and was rich in copper from about 35 fathoms until about 70 fathoms from the surface; that is, through the lower part of the upper deposition of granite, and the subjacent schist; but at about the place where it entered the granite again it was hard and poor. It was pursued for about 100 fathoms in depth. The ore was a mixture of yellow and grey, and like that of every other vein in the mine, was so extremely bunchy, that a regular course of ore, as it is technically termed, could scarcely be said to have existed in any part of it. Dunkin's vein varied from one to twelve feet in width, and its general underlie differed so little from the perpendicular, that advantage was taken of that circumstance to sink the shaft on its course. It was poor at the points of junction with Martin's and Bodilly's veins, but some ore was found in it between them. It was richer below the latter, and was worked to the depth of about 125 fathoms from the surface. Martin's vein was from about 3 to 6 feet wide, and yielded abundance of yellow ore (from which brilliant specimens were selected in tetrahedral crystals of considerable size) and was worked to about 100 fathoms from the surface. Bodilly's vein varied from one to six feet in width, the ore was yellow, the vein was for the most part poor and hard, and was worked to the depth of about 125 fathoms. The load, or substance, of the South and Dunkin's veins, passed through the New Tin vein, which, a little below the latter of them, yielded a considerable quantity of tin, as it did also at about 70 fathoms from the surface; in the intermediate space it likewise yielded tin, with a very small quantity of copper, but was far from rich. It was pursued for about 90 fathoms in depth. In the small vein on the south of Chapple's vein some tin was found, but the quantity was not considerable. Chapple's vein varied from one to three feet in width, and yielded yellow copper ore, interspersed with large quantities of iron pyrites. It was worked to about 100 fathoms from the surface, as was also the Highburrow vein, which varied from six to twelve feet in width, and yielded both tin and copper, either intermixed or running side by side down the vein: the latter was both yellow and grey, and very abundant. The old vein is very large, and was very productive of tin for about the depth of 45 fathoms from the surface, when it became poor, and was found to contain little else than iron pyrites. But as this vein, during many years, proved immensely rich in copper when passing through Cook's Kitchen mine, which is contiguous to Tin Croft on the west, little doubt is entertained by miners that it will also be found rich in copper at a greater depth than it has hitherto been proved in this mine. To Captain Thomas Teague, of Redruth, an experienced and very intelligent miner, and who during many years has principally conducted the working of Tin Croft mine, I am indebted for the Section. He informed me that in some part of Dunkin's vein, granite was found on one side of it and schist on the other, and that detached masses of each substance were found both in it and in the South vein; and frequently, that where granite formed the country on each side of the vein, the masses were of schist, and vice versa.

Description of some of the Veins in the Mines called Tol Carn, Huel Jewel, and Huel Damsel, near St. Die.

Pl. 6. Fig. 1.

The veins of these mines are remarkable in several respects. A small brook was the boundary between Huel Jewel, which had been worked about fifty years at an immense profit, and that of an untried mine called Tol Carn, near St. Die. The veins of Huel Jewel were very rich in those parts which adjoined Tol Carn mine. This, of course, raised the expectation of the adventurers in the latter to an extraordinary pitch, and they set to work in the full belief that they should be at little trouble and expense in realizing on their side the brook, a continuation of the riches on the other side, as the veins of Huel Jewel made immediately for Tol Carn mine. On sinking a shaft in order to cut one of them at a certain depth, they were surprised at not doing so, since from knowing the precise run of the vein, the miner is generally able to make nice calculations in point of depth and distance in the sinking a shaft. After this had been done, as far as it was deemed proper, they drove through the country, at right angles with the shaft, from north to south, several fathoms without finding the vein. It was then attempted, by sinking shafts, to cut the other two veins which formed a part of the workings of Huel Jewel, but without success. After much labour and expense had been bestowed, it was discovered that underneath the brook forming the boundary between the two mines ran a cross vein of flucan, varying from a few inches to a few feet in thickness; this vein is believed to run quite across the country from sea to sea, heaving, in the phrase of the miner, all those parts of the veins, which it is known to intersect, on the western side of it, higher north than those on the eastern side; so that those parts of the veins in Tol Carn mine had been heaved by it full eighty fathoms higher north than the other parts of them in Huel Jewel, which however were found to correspond with those in Tol Carn not only in their respective distances but also in dimension. One circumstance however that added materially to the strange consequences of the cross vein was, that although the veins in Huel Jewel were rich quite to the cross vein, those in Tol Carn mine were almost without a speck of ore in them: it was therefore abandoned after a great expense, and consequently a great loss has been incurred.

Parallel with the veins of Tol Carn mine, but on the south of it, run the veins of the rich copper mine called Huel Damsel; these have not, I believe, been wrought quite home to the Great Cross vein. By the annexed ground plan it will be seen that a vein of flucan, varying from 2 inches to 2 feet in thickness, but without any perceptible underlie, that is to say, going down in a direction about perpendicular to the horizon, ran nearly north-east and south-west, intersecting the veins of Huel Jewel, the Great Cross vein, and the veins of Huel Damsel, and, to use the miner's phrase, heaving them, in the directions laid down in the plan about two fathoms from their strait courses. This vein is by the miner called a flucan.

It should be noticed that in the working of the above mines, their veins were discovered to be intersected near the Great Cross vein apparently by two or three smaller cross veins, between which parts of the east and west veins have been seen; as however the Great Cross vein is known in other parts of it to divide into branches (a circumstance very common in veins of this description) it is believed that these small veins are only branches of the large one. The whole of these mines are situated in granite.

Ground Plan of some of the Veins in the Copper Mine called Huel Alfred.

Pl. 6. Fig. 6.

This mine is situated on a schistose hill, in the parish of Phillack, about three miles south-east of Hayle Copper-house. It had been worked previously to the year 1800, but was abandoned principally on account of the surrounding country having fallen in, and filled up or destroyed the only shaft that had been sunk. This circumstance was, most probably, the cause to which the successful working of the mine may be attributed. For, being compelled to sink another shaft, it so happened that the chosen spot was immediately above a vast body of ore which has never failed since its discovery. But as copper ore had been left at the bottom of the shaft that had fallen in, a level was carried to that place; it was however found to be a mere bunch, which circumstance, it is most probable would have deterred the miner from an effectual search after the great riches pitched upon by sinking the new shaft about 100 fathoms west of the former one.

Notwithstanding Huel Alfred is one of the richest and most profitable copper mines that Cornwall has now to boast of, a particular description of some of its veins would not have been now attempted, but for some circumstances worthy of particular notice, viz. that one of its veins is of that description termed a contre, remarkable for its magnitude and riches as well as its direction, and on account of the effects produced by its traversing an east to west vein, and a north and south vein, or cross course.

Both the shafts above alluded to were sunk on the contre, the direction of which is 28 degrees south of east and north of west. It varies from 9 to 24 feet in width, its underlie is 2 feet in a fathom to the east of north. At a small depth this bore the appellation of a 'Flucany Load.' Flucan prevailed very much between the depth of 50 and 70 fathoms from the surface, and burst out occasionally with such vehemence as to drive away the workmen. Captain Samuel Grose, an intelligent captain of the mine, informed me that he was once carried away 7 fathoms by its sudden irruption. But little flucan was seen at much greater depth. Beneath it and above the copper very great abundance of sulphuret and carbonate of lead occurred, together with iron pyrites, blende and quartz. The greatest extent to which the contre has been worked is 160 fathoms from its junction with the east and west vein towards the south east; 90 fathoms of which, at about 130 from the surface, are good ore. The only place at which the contre was rich when in contact with the east and west vein, was at about 117 fathoms from the surface. North-west of its junction with that vein the contre was small, and for more than 100 fathoms in depth consisted of strings of flucan, but at about the depth of 120 fathoms it enlarged to twelve feet in width and yielded some ore, mingled with fluor, blende, and iron pyrites in abundance; at 130 fathoms in depth, it was poor for 20 fathoms from its junction with the east and west vein, and then succeeded 40 fathoms of what the miner terms *orey ground.*

It seems to be the opinion of a very intelligent and experienced miner, Captain John Davey, who was a captain in Herland mine, and is now the managing captain of Huel Alfred, that the contre of the latter is a continuation of that of Herland.

The east and west, or regular metalliferous vein averages about $2\frac{1}{2}$ feet in width, and runs 10 degrees south of east and north of west: it underlies $2\frac{1}{2}$ feet in a fathom towards the north. The ore was about 110 fathoms in length east of its junction with the contre, but the east and west vein is poor every where when in contact with it, except at the only place at which also the contre is rich, viz. at about 117 fathoms from the surface.

West of the contre the east and west vein is lost for nearly 30 fathoms; and when discovered again, it varies from 18 inches to 4 feet in width and its load was found chiefly to consist of flucan with some blende.

The ore of the contre is yellow and occasionally compact, but it is for the most part approaching to black externally; and where richest, is loosely intermingled with small portions of quartz, blende, and iron pyrites, which prevailed very much near the surface.

The ore of the regular vein east of the junction with the contre is also yellow, and for the most part hard; but it is occasionally loose.

The common effect of a cross or north and south vein is that it passes through the east and west or metalliferous vein, and mostly alters its course, of which numerous instances are shewn on the ground plan of Herland, Drannack and Prince George Mines. A cross vein occurs in Huel Alfred; its effect on the east and west vein is not yet known, but a rare exception to the general rule of north and south veins traversing metalliferous veins is here exhibited, for the load of the contre, which, as has been said, is rich in copper, not only passes through the north and south vein, but also heaves it out of its regular direction four fathoms. This is the only instance of the kind that has come to my knowledge. On consulting the ground plan of Herland and Drannack mines, it will be seen that the effect of the cross vein on the contre in that mine was exactly that of the contre on the cross vein in Huel Alfred.

The run of the cross vein is direct north and south ; it underlies west about one foot in a fathom ; is nine feet wide, and close to the contre (where only it has been seen) is chiefly filled with quartz, accompanied by blende and carbonate of lead in very small quantities, but in it there is no flucan ; at and below forty fathoms from the surface, the quartz assumed the form of a fine sand, and the water from the cross vein was so powerful as to wash the sand 90 fathoms into the contre, so as occasionally to choak the pumps. It should be remarked that no ore was seen in the latter while passing through the cross vein for more than 100 fathoms from the surface.

About 45,000 tons of copper ore, the produce of Huel Alfred, have been sold since the beginning of 1801, for the sum of about £350,000. The number of men women and children, employed underground and on the surface, amounts nearly to 1500. There are three large steam engines for drawing the water, and two steam whims for drawing the ore, now on the mine. The monthly expenses for labour, coals, ropes, timber, &c. amounts now to about £5300. The profit hitherto divided amongst the adventurers amounts to about £120,000.

VII. *On the Freshwater Formations in the Isle of Wight, with some Observations on the Strata over the Chalk in the South-east part of England.*

By Thomas Webster, Member of the Geological Society.

INTRODUCTION.

AMONG the geological researches which have lately been made in various parts of the globe, none have been more interesting than those of M. M. Cuvier and Brongniart in the environs of Paris.

These naturalists have described a series of mineral strata differing in many respects from all that were formerly known, and particularly distinguished by their numerous and singular organic remains. The animals whose exuviæ had hitherto been more commonly noticed in regularly stratified rocks were the inhabitants of an ocean: but many of the Parisian fossils belonged to freshwater lakes and marshes, thus developing new and unsuspected agents in the forming of mineral beds.

The strata described by the French naturalists are deposited in a cavity in the chalk stratum which extends through a considerable part of the north of France. The bottom of this hollow is extremely irregular; and before it was covered by the materials now found in it, must have presented partial cavities and projections, the latter appearing as so many islands piercing through the other strata;* and it is an important observation that there is no correspondence between the irregular form of the bottom and that of the present surface of the country.

Although the number of distinct beds or layers in this basin is very considerable, yet the authors of the memoir have reduced them to eleven principal classes.

1. Chalk.
2. Plastic clay.
3. Coarse limestone and sandstone.
4. Siliceous limestone.
5. Gypsum and marl, containing bones of animals, forming the lower freshwater formation.
6. Marles of marine origin.
7. Sand and sandstone without shells.
8. The superior marine sandstone.
9. Buhr or millstone formation without shells, and argillaceous sand.
10. The upper freshwater formation, comprehending marles and buhrs with freshwater shells.
11. Alluvium or earth of transportation, both ancient and modern, analogous to our gravel, &c. comprehending rounded pebbles, pudding stones, argillaceous marles and peat moss.

Of these the three first above the chalk are of marine origin, and they cover the whole of the bottom of the basin.

The gypsum and accompanying marles they imagine to have been formed chiefly in fresh water, from the fossils contained in them.

The next series of marles and sandstones containing only marine shells, shows the sea to have again covered the last formed strata.

Lastly, the upper freshwater formation demonstrates this place to have been a second time converted into a lake.

Such are the leading features of these remarkable strata.

It is the object of the present paper to describe a similar series of formations; from which it will appear that the circumstances which gave rise to the alternation of marine and freshwater strata were subject at distant places to the same general laws, and were therefore extensive in operation: conclusions in themselves not uninteresting, and tending to throw some light on the later revolutions which our planet has undergone.

Sir Henry Englefield was the first who observed a range of chalk hills running from east to west across the middle of the Isle of Wight, and inclined at an angle of from 60° to 80°. An account of these strata appeared in the Transactions of the Linnean Society, 1802;* but circumstances having prevented him from prosecuting these geological researches in person, at his request in the summer of 1811 I examined the connexion of the vertical strata of the Isle of Wight with those on each side which are horizontal, and also the continuation of this range to the west on the opposite shore of Dorsetshire.

The general result of this enquiry will be best understood from the following section across the Isle of Wight from north to south; see plate 9, fig. 1.

The inclined strata A, B, C, D, E, compose a range of hills that divides the island into two parts, extending from the Needles at the west end of the island to the Culver cliff at the east: at which places may be seen vertical sections at right angles to the direction of the range.

* A detailed description of the Isle of Wight is now preparing for the press by Sir Henry Englefield, who has permitted me to communicate to the Society many of the observations which I made at his request with the view of completing his work.

The stratum marked A, is chalk with flints,* which at the north side is in nearly vertical layers, the inclination becoming gradually less and less towards the south side, where they dip about 60°.

B is chalk without flints.

C chalk marl.

D calcareous sand-stone, with subordinate beds of limestone and chert.

E bluish-black marl.

F ferruginous sand and sand-stone, with potters' clay, slate clay, argillaceous limestone, wood-coal, &c. The part of this stratum in the middle ranges of hills inclines only a few degrees, extending to the south side of the island, where it is horizontal. It is to be remarked, that towards this side of the island there is a higher range of hills H, composed of horizontal strata which correspond exactly with a part of those of the highly inclined series of the middle range, not only in their nature, but in their order of superposition; thus irresistibly forcing upon us the conclusion, that they belonged to the same formation, and that they had probably at some period been continuous.

The strata G, to the north of these already mentioned, consist of a numerous alternating series in a vertical position, and are composed chiefly of sand and clay. These may be seen to great advantage in Alum bay, where they form cliffs about 200 feet in height.

The whole of the most northern part of the island, I, consists of nearly horizontal strata, which come up abruptly against those that are vertical, but are slightly curved at their junction with the latter. These, however, proved to be entirely different in their mineralogical characters and in the fossils which they contained, from the strata

* It was this chalk, together with the vertical strata of Alum bay, and the horizontal strata on each side, that were first observed and described by Sir H. Englefield.

that I have described on the north side of the island, under the chalk.

Several of them were composed of a calcareous rock, either of a loose or compact texture; and an attentive consideration of this section, together with those of the opposite coasts of Dorsetshire, Hampshire, and Sussex, convinced me that the date of their origin was posterior to that of the chalk.

No distinct limestone stratum had been hitherto observed above any part of the chalk in this country, although it was well known that such were frequent in France. That this is the real position of the limestones near Paris could not be doubted, since the chalk is always reached in sinking to great depths. But the geognostic place of the strata on the north side of the Isle of Wight, was more difficult to ascertain; and it was only from many combined considerations that I was led to the conclusion, that they might be found to agree with some of those lately described by Cuvier and Brongniart, as contained in the basin of Paris.

These considerations were the following:

The chalk of England, although it appears upon the surface only in detached hills and patches, is actually continuous through considerable tracts of country, where it exists at great depths, as is now ascertained by numerous wells and other sinkings. In the order of position, which the strata of the chalk itself, and those which lie above and below it, bear severally to one another, there has been observed in distant places a remarkable agreement. And although occasional varieties may be noticed, in consequence of the defect or redundance of any one stratum, yet the law of the Wernerian school seems to hold good; viz. that the order of the beds is never inverted.

This agreement renders it extremely probable that the corresponding strata, found in different parts of the same country, arose from the same cause, and at the same time; and favours the idea, that many of these, although now broken and unconnected, were originally continuous.

A part of the series which I deduced from observations made in the south-eastern part of England, is as follows, beginning with the uppermost.

1. Alluvium, consisting of gravel, loam, sand, &c. and forming the surface or soil.

2. Sand seen chiefly in the neighbourhood of Bagshot.

3. Blue clay, with septaria and marine fossils, commonly called the London clay.

4. Sand, plastic clay, &c.

5. Chalk with flints.

6. Chalk without flints.

7. Chalkmarl, including what is called the grey chalk.

8. Sandstone with green earth and mica, cemented together by calcareous matter, and containing subordinate beds of limestone and chert. This includes the firestone of Ryegate, and Kentish rag.

9. Blueish black marl.

10. Sand and sandstone, highly ferruginous, containing subordinate beds of clay, fullers earth, shale, bituminous wood, and limestone. This stratum forms the wealds of Kent and Sussex.

11. A series of strata of shelly limestone, known by the name of the Purbeck stone, alternating with shale and marle. Some of the fossils of these strata strongly resemble freshwater shells: they appear to be the Cyclostoma, Planorbis, &c.

12. Clay with gypsum.

13. Portland oolite.

14. Clay with limestone and bituminous shale, containing the Kimeridge coal.*

The strata of Alum bay, now seen in a vertical position, must have been originally quite horizontal, or nearly so. For it is not only extremely improbable that beds of such materials should have been found in any other manner, but a circumstance which I noticed in Alum bay renders certain the original position of the sand and clay strata. In one of the vertical beds, consisting of loose sand, are several layers of flints, extending from the bottom to the top of the cliff; these flints have been rounded by attrition; are from one inch to eight inches in diameter, and appear to have belonged to the chalk. Now it is inconceivable that these flint pebbles should have been originally deposited in their present position; and they distinctly point out the original horizontality of this series. There are no signs of partial disturbance in the several beds, and it appears therefore that the whole has been moved together, either by elevation or subsidence into the vertical situation.

The strata of chalk have evidently suffered a change of position at the same time with the clay and sand; and since the vertical beds of Alum bay, G, are next to the stratum of *flinty* chalk, which, according to the regular order of superposition, is known to have been the uppermost of the chalk series, it follows, that they are of posterior formation. Moreover, the most northern of these vertical beds is a blue clay, agreeing with the London clay, a bed which always lies over the chalk.

* Other divisions of these strata have been made, and the cause of the differences has already been alluded to. Not every member of the series is perfectly continuous or of uniform thickness; so that when any one is wanting, beds, usually separate, are brought into immediate contact. In making a classification of these beds, those should be considered as principal members, which are most rarely deficient in an extensive tract of country.

The chalk of the middle hills of the Isle of Wight dipping to the north, and that of the South Downs dipping to the south, it was an obvious inference that it might pass under the channel called the Solent, thus forming a basin. This idea was rendered still more probable on finding that the bottom of this channel consisted mostly of the London clay, which stratum is found under Portsmouth, whence it may be traced eastward, forming the lowermost bed next the sea all along the shore of Sussex to Pagham and Bognor, and westward to Stubbington cliff, and along the coast of Hampshire to Hordwell and High cliffs. In all its characters and fossils, this bed was found to agree with the blue clay which lies over the chalk, in the counties of Kent, Surrey, Middlesex, Essex, &c. and with the most northerly of the vertical beds of Alum bay.* Besides, the chalk itself lies at no great depth from the surface in all that part of Sussex south of the South Downs, and is even found on the shore at lowwater-mark at Middleton, two miles east of Bognor.

It appears, therefore, that between the vertical chalk-hills of the Isle of Wight and the South Downs there is a basin or hollow, occasioned by the disturbance of the whole mass of strata from below the chalk to the London clay, inclusive: and also that this disturbance took place at a period subsequent to the deposition of the last-mentioned stratum, since it is amongst those which have suffered a change of position.

From this it will be readily admitted, that all the beds situated within this basin lie above the London clay, and are posterior to it. Of this description are the horizontal beds of the most northerly part of the Isle of Wight; and since they come almost into contact

* Having by the kindness of Mr. Holloway, of Portsmouth, become familiar with the fossils of Stubbington, I readily perceived their agreement with the above-mentioned stratum in Alum bay.

with the vertical beds without suffering any considerable change in their dip, it should seem that they have been deposited on the sides of this basin subsequently to the disturbance of the strata already spoken of.

The above conclusions are confirmed by other circumstances.

These horizontal beds have no agreement with any of those beneath the chalk, nor indeed with any others yet observed in Great Britain; their mineralogical characters, and their fossils, are peculiar and distinctive. The calcareous beds contain numerous petrefactions of freshwater shells, and in others are found marine fossils agreeing with those described by Lamarck in the strata of the Paris basin. But fortunately, the inspection of specimens from the basin of Paris enabled me no longer to depend upon conjecture only as to the similarity of these formations. They had been given by M. Brongniart himself, in illustration of his memoir, to the Count de Bournon, who had deposited them in the museum of the Geological Society. The agreement of the strata of the two basins, not only with respect to the external characters of the *calcaire d'eau douce*, but also to its fossils, was thus rendered evident: and these specimens, so well authenticated, added one more proof (if more could be wanting) of the utility of such collections, and of the advantages to be derived from a liberal communication between men of science.

It is unnecessary to inform the Society that this circumstance produced another visit to the Isle of Wight and its vicinity, for the purpose of examining more particularly its basin, and the remains of its antient lake. From this, compared with my former survey, I was enabled to add to the British strata the following, of later formation than the London clay.

1. A calcareous stratum, containing only freshwater shells.

2. Greenish marl, with marine shells.

3. Marl with freshwater shells.

4. Dark blue clay without shells.

These must be placed between the alluvium and the London clay, of the former list.

In the subsequent pages I shall describe more minutely the form of the basin of the Isle of Wight; and also that of a similar basin on which London is placed. I shall enumerate the strata and principal organic remains contained in each, and conclude by pointing out such circumstances of agreement or difference as I have been able to observe between them and the Paris basin.

II. *Extent of the Isle of Wight Basin.*

In tracing the margin of the cavity in which these horizontal depositions of the Isle of Wight are found, I shall begin with the south side.

The middle range of chalk hills in this island, together with the other highly inclined strata of Alum bay, form part of the ancient border. If we sail west from the Needles in the Isle of Wight, to Handfast point in Dorsetshire, we shall find that this vertical chalk range again makes its appearance in that coast, and may be traced thence through Corfe Castle to some distance beyond Lulworth; and from the correspondence in the line of direction of the Isle of Wight hills with those of Dorsetshire, and the general agreement in the position and nature of the strata, (the section of the Isle of Purbeck corresponding nearly to that of the Isle of Wight,) it appears extremely probable that at some former period these places were united.

The clay however over the chalk, and part of the chalk itself, in Dorsetshire, is horizontal, differing in this respect from their position in Alum bay. There must, therefore, have been some twist in the chalk stratum, a remarkable instance of which I discovered at the other end of the chalk range beyond Lulworth.*

Since I shall have a future opportunity of making some remarks on the very singular stratification of these places, I shall only at present observe, that the highly inclined chalk from the Culver cliffs at the east end of the Isle of Wight to White Nose, in Dorsetshire, 5 miles west of Lulworth, formed the southern side of this depression in the chalk stratum. The north side of it may be traced in that range of hills called the South Downs, extending from Beechy Head, in Sussex, to Dorchester, in Dorsetshire. The strata of which these hills are composed, dip generally from 15° to 5° to the south; the inclination varying in different places. The south side of the basin therefore must have been extremely steep, while the slope of the north side was very gentle. The closing of this basin at the west is obscure, and cannot be distinctly traced; but the east is now entirely open, the sea passing through it.

III. *Extent of the London Basin.*

This extensive basin, like that of the Isle of Wight, is probably owing to a depression in the chalk stratum.

Its south side is formed by a long line of chalk hills, including those of Kent, Surrey, and Hampshire, called the North Downs, extending through Basingstoke to some distance beyond Highclere

* The drawings and description of this, as well as of many other parts of this remarkable coast, will be found in the above-mentioned work now preparing for publication, by Sir H. Englefield.

Hill, in Berkshire. Its western extremity is much contracted, and seems to lie somewhere in the vicinity of Hungerford. Its north-western side is formed by the chalk hills of Wiltshire, Berkshire, Oxfordshire, Buckinghamshire and Hertfordshire. The most northern part of this boundary has not yet been well determined. On the east it is open to the sea, the coasts of Essex, Suffolk and Norfolk, being sections of the strata deposited in it.

The dip of the chalk of the North Downs from Dover to Guildford is from 15° to 10°, but in the narrow ridge of chalk called the Hog's-back, extending from Guildford to Farnham, the dip is very considerable being above 45°.* On the dip of the other sides I have had no opportunity of making any observations.

The depth of the chalk below the surface at London must be very considerable, since though wells have been sunk several hundred feet it has never been reached; but at a few miles south of the metropolis the chalk is frequently come to.

IV. *Description of the Strata composing and contained in the Isle of Wight and London Basins; with a comparison between them and those in the Basin of Paris.*

The authors of the French memoir, in order to obtain their general section, have collected the sections of various places; and by comparing them together have developed those alternations of marine and freshwater deposits, which are analogous to those we are now considering. I shall follow nearly the same method; but for greater simplicity I shall divide the formations composing our basins into

*For the pointing out of this fact, as well as for much important information respecting the extent of the chalk, I am indebted to G. B. Greenough, Esq. V.P.G.S.

1. *Chalk formation.**

2. *The lowest marine formation over the chalk, including the plastic clay and sand, together with the London clay.*

3. *The lowest freshwater formation.*

4. *The upper marine formation.*

5. *The upper freshwater formation.*

6. *Alluvium.*

Fortunately the complete series of these alternations may be seen at one place in the Isle of Wight, which leaves us no room to doubt their superposition; and when their characters have been studied in this spot, it is more easy to become acquainted with them in other places.

§ 1. *Chalk Formation.*

The south-east coast of England and that of the Isle of Wight afford us many excellent opportunities of examining the chalk. In numerous natural sections formed by cliffs, as well as in chalk pits, I have observed it as distinguished into at least three strata, each of which has peculiar and distinctive characters.

The *lower stratum* is more or less argillaceous, and constitutes what is called the *chalk marl.* Together with the other strata it frequently forms cliffs of considerable height, and though differing little from them in colour is easily distinguished by its constantly shivering with the frost, which always pulverizes a mass of it when exposed to the air for a few months; whereas the others resist the weather in a much greater degree, and are often even employed as a material for building.

* In using the word *formation* I have followed the example of M. M. Cuvier and Brongniart, who have employed it to express an assemblage of beds of the same nature, or of a different nature but formed during the same epoch.

This chalk marl is never quite so white as chalk, having generally a tinge of yellow, and sometimes of grey and brown. It also contains nodules and beds of a more indurated marl, which is usually called the *grey chalk* from its dark colour, which varies from a light to a dark grey and brownish grey. Like all argillaceous limestones it possesses in a considerable degree the property of setting under water when calcined and made into mortar; and it has been used with great success for this purpose in building the London Docks. The part easily reducible to the pulverulent state by the moisture and frost is a most valuable manure when employed judiciously in certain soils. This stratum contains no flints.

The *middle and upper strata* consist of chalk of extreme whiteness and purity, and are chiefly distinguished from each other by the upper one containing layers of flint nodules which do not occur in the lower. The chalk *without flints* is most frequently somewhat harder than that *with flints*, and hence they are sometimes distinguished as the *hard* and *soft* chalk; but from some observations which I have made in Dorsetshire, it will appear that the hardness, or degree of induration, does not always mark a particular bed, the flint chalk being in some places much harder than that without flints in others.

On the subject of the nodules and laminæ of flint in the upper chalk, the observations of Sir Henry Englefield have thrown great light, and will be mentioned in his intended work on the Isle of Wight.

The several beds of these chalk strata, which vary in thickness from a few inches to several feet, are frequently separated from each other not only by layers of flint nodules but frequently also by a marl containing a considerable proportion of clay, and this substance also sometimes fills up the diagonal fissures which cross the strata.

The workmen take advantage of this circumstance in quarrying the chalk.

The description given by M. M. Cuvier and Brongniart of the chalk of France appears to agree generally with that detailed above. They mention nodules of a harder chalk as occurring in layers in a softer. They observe that Werner has enumerated grey and brown among the colours belonging to chalk: and that in a great part of Champagne the chalk contains no flint,* but it does not appear whether these varieties of chalk are on the continent confined to particular strata.

M. M. Cuvier and Brongniart remark that the chalk which forms the bottom of the Parisian basin, appears to have been consolidated before the deposition of the clay which covers it: a circumstance which they inferred from there being no transition of these into each other. A breccia is described as occupying the lower part of the basin at Meudon, composed of water-worn fragments of solid chalk cemented by a paste of clay, and situated between the chalk and the plastic clay. This circumstance, together with the irregular form of the bottom of their basin, seems to indicate a considerable action of water upon its surface, so as to render it now difficult to ascertain what might have been the last deposi-

* A singular circumstance is mentioned respecting the chalk of France to which we have nothing analogous in this country. In Champagne there are immense plains of chalk absolutely deprived of vegetation, except where patches of the calcaire grossier occur as islands or oases in the midst of these deserts. And M. Cuvier observes that many parts of this tract have not perhaps been visited for ages by any living being: no motive existing that could induce any to wander there. In England every part of our chalk is completely covered by vegetable soil, which although very thin on many parts of our downs or smooth hills, yet affords support to peculiar grasses and other vegetables, on which are pastured vast quantities of sheep. The chalk of France is said to contain 11 per cent. of magnesia, to which the barrenness may be owing.

tions of the chalk formation, or those which immediately succeeded it.

Some appearances shew that a similar action had taken place on the original surface of our chalk. Many very interesting sections may be seen in the County of Kent, where the chalk being at no great depth, its junction with the strata over it may be very conveniently studied. At Woolwich, on the top of the chalk, and between it and the superimposed sand, there are a number of flint nodules heaped on each other, which have evidently been displaced from their original matrix. In the numerous chalk pits, and where the roads are cut through the chalk along the south side of the Thames, as at Rochester, Gravesend, North Fleet, Greenhithe, &c. the junction of the chalk with the sand and gravel is remarkable for the deep indentations in the surface of the former, which upon examination I ascertained to be the sections of long furrows and of wells; these were apparently occasioned by the powerful action of water prior to the deposition of the sand and gravel which now fills up these hollows: the same may be seen still better at Purfleet.

The present surface of the chalk stratum is also frequently covered by water-worn pieces of chalk and flint imbedded in clay or alluvial deposits.

The cliffs between Brighton and Rottendean are of a singular character, and merit a particular description. The shore consists of the solid chalk, which is seen running out to a considerable distance into the sea, and dipping a few degrees to the south. This stratum forms six or seven feet of the lower part of the vertical cliff; and on that are placed several layers of loose flints, evidently rounded by attrition and piled on one another. Over this is an irregular bed consisting of pieces of chalk and smaller pieces of flints, both of which have undergone the same process; and the interstices are filled up with clay and loose chalk or marl: over this is another layer of pebbles, and again clay and chalk and fragments of flints; and these follow in succession, but very irregularly, to the top of the cliff, which is at least seventy or eighty feet in height. These materials are in general quite loose, being simply heaped or laid on each other; but sometimes masses of it are cemented together by stalactitical matter, and when the cliff falls, form blocks of great size and hardness.

It is impossible to see this cliff without immediately perceiving that it does not owe its existence to original stratification; but that it is simply the section of an immense heap of fragments of chalk and flints mixed with clay and sand, the whole of which has at some distant period been subjected to the action of water; and that it has been thus deposited upon the solid chalk stratum which is now seen below it.

In tracing this vast collection of water-worn materials, we find that it forms a considerable hill behind the town, and that it joins to the side of the range of hills called the South Downs.

In Alum bay in the Isle of Wight, however, the stratum immediately next to the flinty chalk, and consequently deposited upon it, consists of a white chalk marl without flints. Its nature is sufficiently shewn by its pulverizing with the frost; and the rains wash it down, so that its situation is marked by a deep hollow. There is some appearance here therefore of a transition of the last portions of the chalk into the clay which succeeded it; and, the usual rounded flint pebbles over the chalk and the other signs of disturbance being there wanting, it is possible that we have in that place the original succession of depositions. In many parts of Sussex also, south of the South Downs, as at Emsworth, Lavant, Siddlesham, South and North Bersted, Middleton, &c. I found pits of a marle without flints, and which is evidently over the chalk. The same marl is also to be found in Dorsetshire west of Corfe Castle. I have not however heard of its existence in the London basin.

The agreement of the fossils of our chalk with that of France has been already pointed out by Mr. Parkinson in his Memoir "on some of the Strata in the neighbourhood of London," in the first volume of the Transactions of this Society. In the following lists I have been favoured by his assistance in the endeavour to appropriate the fossils to their peculiar beds.

In the Chalk with Flints.

Asteriæ resembling
- Pentagonaster semilunatus
- ——————— regularis
- Pentaceros lentiginosus
- Stella lumbricalis, lacertosa, corpore spherico.

Echini of the following families:
- Cidaris,
- Cassis,
- Spatangus,
- Fibula,
- Conulus,

} several species.

Spines of the foregoing: particularly those resembling the belemnites as described by Mr. Parkinson.

Serpulæ, particularly the serpula of Mr. Parkinson's organic remains, vol. 3. pl. 7. fig. 11.

Cardium.

Spondylus.

Ostrea, several species.

Pecten, several species.

Chama ?

Terebratula, many species.

A longitudinal transversely rugose ostrea-form bivalve of a fibrous structure.

Fragments of another fibrous shell of a large size, of an unknown genus. See Park. Organic Rem. pl. 5. fig. 3.

Alcyonia, sponges, and numerous unknown zoophytes.

A ramose madrepore.

Several species of minute encrini, figured by Mr. Parkinson.

In the Chalk without Flints.

Echini: several of the same families as those in the chalk with flints. Many of them, however, particularly the Cassides, differing much in their forms from the above.

Spines of echini: and particularly those described by M. Braard as resembling the belemnite.

Patella.

Trochus.

Serpulæ, several species.

Belemnites.

Lima ?

Fish, too much mutilated to ascertain the genus.

Palates, scales, vertebræ and teeth of fish.

Cancri.

*In the Chalk Marl.**

Ammonites: the contour of the spiral varying from the circular to the long-elliptical.

* On the authority of Mr. Parkinson I notice that the supposition of having discovered a specimen of Trigonia in chalk is erroneous. This belongs only to inferior strata.

Scaphites: a new genus by Mr. Parkinson. See his Organic Remains, vol. 3.

Turrellites, three species.

Trochus.

Madreporæ.

It has been remarked by the French naturalists that in their chalk there is not any univalve shell with a simple and regular spire. In the chalk of this country, univalves, as the trochus, do sometimes occur. They may probably however be rather the fossils of the green sand below the chalk, which have been enveloped in some of the depositions of the chalk formation, or in the chalk marl, for they are frequently accompanied by green earth.

The following Fossils are found in the Chalk in the Environs of Paris.

Belemnites - - - - -	Perhaps two species: they appear to be different from those in the compact limestone.
Lenticulites rotulata.	
Lituolites nautiloidea.	
——— difformis.	
Pinna - - - - - - - -	It is not certain that the large fragments of 12 millimetres in thickness and of a fibrous texture, which are found in the chalk belong to this genus. M. Defrance has portions of a hinge which indicate a different genus. Cuv. p. 11.

Mytilus - - - - - - -	very different from those of the calcaire grossier.
Cardium ?	
Ostrea vesicularis.	
——- deltoidea.	
Pecten - - - - - - -	M. Defrance has observed 2 species.
Crania - - - - - - -	It was adherent and differing in that from known species.
Perna ?	
Terebratula, many species.	
Spirorbis.	
Serpula.	
Ananchites ovatus - - -	The shell is changed into calcareous spar, and the internal part is converted into flint.
Spatangus Cor anguinum Kl.	
Porpites.	
Caryophyllia	
Millepora - - - - - -	These are often in the state of brown oxide of iron.
Alcyonia.	
Shark's teeth.	

§ 2. *Lowest Marine Formation over the Chalk.*

The clay and sand cliffs of Alum bay afford one of the most interesting natural sections that can well be imagined. They exhibit the actual state of the strata immediately over the chalk before any change took place in the position of the latter. For, although the beds of which they are composed are quite vertical, yet, from the nature and variety of their composition, from the great regularity and numerous alternations of the layers, and the other circumstances which have been already mentioned, no one who has viewed them with attention can doubt, that they have suffered no change except that of having been moved with the chalk from the horizontal to the vertical position.

The whole of these strata have evidently been formed at the bottom of an ocean, from the nature of the fossils contained in them, which, although entirely different from those of the chalk, are yet all of marine origin.

The chalk, A, which forms the side of Alum bay, (Plate 11. Fig. 2.) is somewhat harder than usual, and the flints are shivered, so as to come to pieces on being taken out.*

Next to the chalk, on the north, stands the bed of chalk marl a, which has been already mentioned.

To this succeeds a thick bed of clay, b, of a dark red colour, often streaked or mottled with yellow and white; towards the south side is a thin layer of greenish-grey sand. This is divided by a bed of yellowish white sand, c, from a very thick bed of dark blue clay, d, which contains much green earth; and also nodules of a dark coloured limestone, in which I found a few fossil shells: this bed, however, I am inclined to think, is not continuous for a great extent, as in a part of the cliff farther inland and in the line of its direction, it had almost disappeared.

Next follows a vast succession of beds of sand of different colours, which, though not distinctly separable from each other, yet may be considered as divided into the following:

* See the paper on this subject, by Sir Henry Englefield, in the Transactions of the Linnean Society.

e, Greenish yellow sand.
f, Yellow sand with ferruginous masses.
g, Greenish sand, like e.
h, Yellow, white, and greenish sand.
i, Whitish sand, with thin stripes of clay.
k, White and yellow sand.
l, Light green sand.
m, Ferruginous sand stone.
n, Yellow sand with a few red stripes.

Next to this, and in the middle of the bay, is a very numerous succession of beds, which contain a large proportion of pipe-clay of various colours, white, yellow, grey, and blackish. These alternate with beautifully coloured sands. The clay is sometimes in beds several feet in thickness, without any admixture, and sometimes in laminæ not a quarter of an inch thick with sand between them. They are generally as follows:

o, Blackish clay with stripes of white sand.
p, Sand intensely yellow.
q, Very white sand. In the middle of this there is a layer of small siliceous nodules, quite white, easily frangible, and of an earthy texture; they are water-worn, and seem to have been derived from decomposed flints.
r, Sand of a crimson colour.
s, Pipe clay with sand stripes. Here it runs into the sea, and may be traced across the beach.
t, Yellow sand with some crimson.
u, Pipe clay, white and black, with stripes of sand. In the middle there are three beds of a sort of wood coal, the vegetable origin of which is distinctly pointed out by the

fruits and branches still to be observed in it. It sometimes splits into irregular layers in the direction of the bed, and the cross fracture is dull and earthy. It burns with difficulty, and with very little flame, giving out a sulphureous smell.

v, Yellow and white sand, with crimson and grey stripes.

w, Five beds of coal similar to that above-mentioned, each a foot thick.

x, Whitish sand and brownish pipe clay.

y, Whitish sand with stripes of deep yellow.

z, Several layers of large water-worn black flint pebbles, imbedded in deep yellow sand.

B, A stratum of blackish clay, with much green earth and septaria. In this green earth are a prodigious number of fossil shells, but in a very fragile state. They correspond exactly with those of Stubbington and Hordwell.

A stream of water from the adjoining hill has worn a deep channel through the stratum, and affords a path down to the bay.

To the north of this, the strata C consist of yellowish sand; and it is not easy to see what is really the position of those beds which lie immediately next to the blue clay, but they appear to dip about 45° to the north; and the sand D lying on them is nearly horizontal.

The north side of Alum bay is bounded by a hill called Headen, about 400 feet high, considerably loftier than the vertical cliffs, and composed of the same part of that series of horizontal strata of which the north side of the island consists. In this hill only do we distinctly see the alternation, I have mentioned of marine and fresh water deposits. It is in a state of constant ruin, and by its section affords lofty vertical cliffs, where its strata may be examined with the utmost facility.

The last mentioned sand is the lowest stratum there visible. It is above 30 feet in thickness, beautifully white, and in it several pits are annually dug, from which the manufactories are supplied with their materials for the best flint glass. This sand may be traced round the foot of the hill on the north side, and forms the bottom of Totland and Colwell bays, dipping gradually to the north.

Over it lies a horizontal bed of black clay E which contains fossil shells, and sometimes selenite.

Upon reviewing the whole of this lower marine series of strata in Alum bay, and comparing it with other sections of the strata immediately over the chalk, we shall find it useful, for the present at least, to separate it into two great divisions: 1. Sand and plastic clay, 2d. London clay. From the irregularities in the beds in the few places where there are good sections, these divisions however can as yet scarcely be considered as distinctly determined. Thus much is certain, that the plastic clay and sand is always below and never above the London clay. Other sub-divisions may be introduced when future observations shall shew them to be sufficiently important.

c'est une seule formation

1. *Sand and Plastic Clay.* From the constant and abundant supply of water which is found on boring through the London clay, and from the accounts of the proprietors of the numerous pits of plastic clay in Dorsetshire, the sand must be considered as the most extensive and continuous formation, and the clay as filling up basins or hollows in it. Hence, as may naturally be expected, we find each of these substances in different places in immediate contact with the chalk. In the Isle of Wight clay is next to it, but in the numerous sections on the banks of the Thames, sand is the lowest, or the clay is wanting.

The beds of plastic clay in the Isle of Wight are of unusual extent and thickness. They extend quite across the island in a vertical position, keeping parallel to the chalk, and appearing again at White-cliff bay on the east end, where they are however much concealed by grassy slopes.

All along the north side of the range of chalk hills which extends from Handfast-point through Corfe Castle, there is an extensive stratum of pipe clay in a horizontal position. It contains a bed of coal so exactly resembling that of Alum bay, that this circumstance, added to the quality of the clay and its geognostic position, is sufficient to identify it.

I have been favoured by Alexander Jaffray, Esq. with the following section of the clay pits of Norden, near Corfe.

Sand on the top - - -	10	feet
Blackish brown clay -	14	
Wood coal - - - -	3	
Refuse clay - - - -	5	
Fine white potter's clay	6	
Dark brown clay - -	2	
Fine white potter's clay	$6\frac{1}{2}$	
	$46\frac{1}{2}$	

The same stratum of clay, though not of equal quality, may be traced in the hills near Poole; and is found in many parts of that extensive tract called the trough of Poole.

Potter's clay, white, yellow, or greyish white, similar to that in the Isle of Wight, is also frequently found in the London basin: some of it is of considerable fineness, as on the east bank of the river Medway, near Rochester.

The plastic clay is frequently of a deep red colour, or red and white mottled, as in Alum bay: a similar red clay is dug near Portsmouth and other places along the South Downs. It also appears at Reading.

In the Isle of Wight basin, both in Dorsetshire and Alum bay, beds of iron stone and ferruginous sand occur connected with this clay, and generally lying over it. Considerable rocks of it are seen about Studland, and the Druidical monument, called the Agglestone; near that place is a huge block of this bed.

A stratum of sand, containing green particles, frequently occurs near the chalk. It is seen in Alum bay without fossils; at Reading it is found containing oyster shells. This green sand is easily distinguished from that below the chalk, as it is never indurated.

2. *London or Blue Clay.* The stratum which has received this de-denomination is found immediately under the gravelly soil on which the metropolis is situated. Of all the strata over the chalk in this country, it is of the greatest extent and thickness: and the number, beauty, and variety of the organic fossils which it contains, renders it the most interesting and the most easily recognizable.

It consists generally of a blackish clay, sometimes very tough, at other places mixed with green earth and sand, or with calcareous matter.

It contains also numerous flat spheroidal nodules of indurated marl, or argillaceous limestone, which lie in regular horizontal layers, at unequal distances, generally from four to ten feet apart. These nodules are well known by the name of Ludus Helmontii, or Septaria, from their being divided across by partitions or veins of calcareous spar, which are generally double. In their cavities are frequently found crystals of calcareous spar and of sulphat of barytes. The septaria are surrounded by crusts which contain a smaller proportion of carbonat of lime than the central part. They often include organic remains.

Besides the clay, marl, sand, and carbonat of lime, of which the main body of this stratum consists, several other substances are dispersed through it in smaller quantities. Of these the chief is sulphuret of iron, which is frequently the mineralizing matter both of the vegetable and animal remains included in the blue clay.

Selenite is also very abundant; and sulphat of iron frequently effloresces when the clay is exposed to the air, from the decompositionof the pyrites contained in it. Phosphat of iron is also sometimes found.

On account of these salts, the water which is contained in, or which passes through this stratum, is not fit for domestic purposes.* Wells are therefore generally sunk entirely through it to the sand below.

In the country round London, this sand which belongs to the plastic clay, is the great reservoir of water, which generally bursts out with great violence when broken into.

Sulphat of magnesia has long been known in the springs at Epsom, which has given its name to this salt. Its origin however does not appear to have been clearly ascertained, although from its situation it may be supposed to belong to some of the beds above the chalk. I derive from Mr. Tennant the information, that the London clay abounds in Epsom salts. The bricks of old buildings in London, after fine dry weather, are covered with an efflorescence of this salt. This may be seen in the walls of the Temple.

In the Isle of Wight, as well as the London basin, this stratum occupies the same situation, and does not appear to differ materially in each of these places. In Alum bay it is seen forming the most northerly of the vertical strata. On the opposite shore of the Solent it occurs in a horizontal position. Sections of it are formed by the cliffs between Lymington and Poole. Of these, Hordwell cliff,

* Hence the country on the northern side of London is so thinly inhabited.

below Christchurch, is well known, on account of its fossils, which are found in a very perfect state. They have been collected and very accurately described by Mr. Brander and Dr. Solander.

At Stubbington, a few miles west of Portsmouth, the same stratum of blue clay with much green earth is visible, in a low cliff, with the same fossils as at Alum bay and Hordwell: the strata being horizontal. The fossils here, as at Alum bay, though numerous, are in a very fragile state; minute nummulites are extremely abundant.

Portsmouth is built upon this stratum, and several deep wells sunk there afford us much information. James Hay, Esq. F.L.S. kindly furnished me with the following account of the sinkings at that place.

"1. Vegetable mould.

2. Yellow loam, of which excellent bricks are made.

3. Yellow gravel, composed of rounded siliceous pebbles and sand, from 4 ft. 6 in. to 10 feet thick. In some places, towards the bottom, the sand abounds; and, generally, within a few feet of the blue clay, is very fine, and in many places is of a greenish colour. In the yellow gravel are found many organic remains, siliceous, and all rounded by attrition. In a few instances singular bones have been discovered.

4. An immense bed of blue clay, which in many places at the surface is mixed with sand strata. At the depth of 30 feet it is traversed by a thin stratum of white pebbles. Many wells are dug to this stratum, which contains water, but of a hard quality. At the depth of 60 feet another similar stratum is found, containing water also, and of a softer quality. No wells had been sunk lower than this last stratum, until within 15 years ago, when a well was dug in the Dock Yard, to the depth of 202 feet. Excellent

water was then found. Another well was dug about a quarter of a mile north from Portsmouth, where water of a good quality was obtained at a depth of 126 feet from the surface. Two years ago a well was sunk in the town of Portsmouth, to the depth of 266 feet, without getting through the blue clay, and they left off without finding water. This is the greatest depth they have gone to in this place. The fossils dug up from these wells agree exactly with those found in other parts of the same stratum."

I traced this blue clay west of Portsmouth by Emsworth and Chichester harbours to Brackelsham; and thence round Selsey Bill to Pagham harbour.

At Bognor it assumes a new character; instead of a blue clay, we find here a number of rocks, now appearing as detached masses in the sea, though evidently forming portions of a stratum once continuous. The lowest part of these rocks is a dark grey limestone, or perhaps rather a sandstone, containing much calcareous matter, enclosing many fossils belonging to the blue clay. The upper part is a siliceous sandstone Bognor rocks resemble much the nodules and beds of limestone that are found in the blue clay in Alum bay, and no doubt are owing to the great abundance of calcareous matter in this part of the bed.

The Barns rocks between Selsea and Bognor, the Houndgate and Street rocks on the west, and Mixen rocks to the south, of Selsea, are portions of the same bed; and I found similar but smaller masses at Stubbington.

From this place to Brighton the shore is quite flat, and the chalk lies at no great depth.

The coast at Brighton has been already mentioned. At Rottendean the cliff towards the sea consists of chalk, and this continues to Newhaven. At this place a series of beds above the chalk occurs, forming to the west of the river a hill, the greatest part of which is now destroyed by the action of the sea. At this place the chalk is about 50 feet in height, and is covered immediately by a bed of sand 20 feet thick. Over this are thin strata of yellow marl and clay, containing a coal much resembling that of Corfe and Alum bay. H. Warburton, Esq. Secretary to the Geological Society, who first noticed and pointed out to me these interesting strata, found impressions of leaves in the marl which exactly resemble those engraved in one of the plates of the Essay on the Mineralogy of the Environs of Paris: and I have since recognised among the specimens brought from that place, a fruit of one of the palm tribe, with the vegetable fibres quite distinct. Shells belonging to the Genera Cerithium, Cytherea and Ostrea, together with pyritous casts of the same, also occur.

With this coal are found thin masses of gypsum both selenitous and fibrous; and over all is a thick bed of blue clay with marine fossils, which are different from those usually found in the London clay.

It was here that I found the singular substance which the experiments of Dr. Wollaston ascertained to be a new mineral, a subsulphat of alumine. It lies immediately upon the chalk, and fills up a hollow in it. About a mile on the east side of Newhaven the chalk cliffs rise again to an equal height and continue to Cuxhaven, where there is a similar interruption, and thence extend to Beachy Head, increasing regularly in altitude, and forming tremendous precipices of several hundred feet in height.* The chalk here is covered only by a thin layer of sand and gravel.

* One of these prodigious falls of the chalk cliffs, which make a residence near them frequently so dangerous, occurred a few days before my visiting this spot, accompanied by a remarkable circumstance. The clergyman of East Dean, who was walking near the brink of the precipice, perceived the ground to give way under him, and had the

Turning round this promontory, the lower chalk and chalk marl are seen at the bottom of the cliff and rising to the north-east, where they soon take place of the chalk, forming a mouldering slope at South Sea houses; they there give place to the green sand, which continues some way, then dips, and is covered by a flat beach extending many miles along Pevensey bay. It is almost needless to observe that the cliffs from Rottendean to Beachy head are oblique vertical sections of the South Downs, and have been formed by the action of the sea.

On entering the London basin at the south side from the sea, after passing the chalk cliffs at North Foreland and Margate, the blue clay makes its first appearance at Reculver; and at Swale cliff and Whitstable it is again seen.

But the Isle of Sheppey, consisting entirely of this stratum, and whose lofty cliffs on the north side furnish very extensive sections, affords the best opportunity for studying it.

Of this island, the northern half consists of a range of hills, of above 200 feet in height. These are cut down vertically by the action of the sea, which occasions the cliffs continually to fall: whole acres of land sometimes coming down at once; in consequence of which, the island must in a course even of a few centuries

presence of mind to escape over the rent that was forming at some distance from the edge of the cliff. In a few seconds, the mass of chalk which he had stood on, to the extent of 300 feet in length, and 70 or 80 in breadth, fell with a tremendous crash. In going from Newhaven round Beachy Head, under the cliff at low water, I passed over these ruins, which were truly terrific, and observed that their fall had been occasioned by the sea acting on the chalk marl, and thus undermining the chalk; the former from the dip of the strata, just begins to appear at the bottom of the cliff at this spot. It may be proper to mention that this place is highly deserving to be visited, on account of the fossils to be seen in the chalk and green sand; among these I remarked many large madrepores, and some very large and entire shells of the fibrous kind, the fragments of which are so numerous in the chalk.

have suffered considerable diminution. The southern half of the island is entirely alluvial, being only a few feet above the level of the sea; and owes its origin to the gradual filling up of the channel which separates the Isle of Sheppey from the rest of Kent. It now consists of flat marsh land, which has been gained from the sea by embankments.

A little to the north of the eastern point, called Shellness, from the great number of recent shells that lie on the shore, a low cliff exhibits the section of the alluvial soil, which consists of clay and gravel. At Warden the high cliff begins on the east, and extends towards Sheerness on the west above six miles in length.

The clay of which these cliffs are composed is in all respects similar to that which has been cut through in the neighbourhood of London at Highgate, and at the Regent's Park; and this place is particularly known on account of its furnishing abundance of the septaria, from which that excellent material for building under water and for stucco is made, known by the name of Parker's cement. These nodular concretions of stone-marl are separated from the clay by the action of the sea, and are collected upon the beach, and exported to various places, where they are calcined and ground.

At Sheerness a well was sunk 330 feet through the blue clay, an account of which is in the Philosophical Transactions: and from this we may obtain an idea of the thickness of the stratum: for to this must be added 200 feet, the height of the cliffs, making in all 550 feet.

The cliffs of Sheppey have long been celebrated for the numerous organic remains found in them, a list of which, added by Mr. Jacob to his Plantæ Favershamienses, is well known. But a much more extensive collection has since been formed by Mr. Francis Crow, of Feversham, who has enriched it by the addition of above 700 different species of fossil fruits, berries, and ligneous seed vessels.

This ingenious and indefatigable collector has also lately ascertained a number of fossil bodies found among them to be the excrescences produced by insects on the branches of various trees; and I have been since favoured by him with a portion of the jaw of a crocodile found in Sheppey; a fossil extremely interesting, since it is the only instance yet observed of the bones of this animal having been found in the London clay.

Almost the whole of the vegetable and animal remains are entirely impregnated with sulphuret of iron, and the vestiges of shells are chiefly casts in this substance. The quantity of fragments of pyritous branches* and fruits is very great.

Among the pyritous casts of shells I found one that much resembled the lymneus, and another the planorbis, but too imperfect to decide the species. It is proper however to mention, that in a late number of the Journal de Physique, in a paper on freshwater shells by M. Braarde, mention is made of three freshwater shells from Sheppey, the lymneus, melania, and nerita.

These shells however, which are very few in number, do not prove the existence of a freshwater formation in this place similar to those of the basins of Paris and of the Isle of Wight: being found among the remains of vegetable and of marine animals, we may suppose that they were carried down together with the branches of trees and fruits by the numerous streams and rivers that must have flowed into this gulph.

Most of the best preserved organic remains are enclosed in the

* It will be an interesting investigation for the experienced botanist to trace the living analogues of these ancient productions of this part of the earth. Such of them as have been recognized are found to belong to species now growing only in the torrid zone; thus adding to the evidence afforded by the animal remains of the great change that must have taken place in the climate.

septaria: in these the shells often retain their original pearly lustre. The nautili are particularly fine.

Boughton hill, between Feversham and Canterbury, consists of the London clay. Still nearer to Feversham fossil shells are found, which are entirely siliceous. They lie loose in a thin bed of greenish siliceous sand that occupies a situation lower than the blue clay, and are separated from the chalk by a thick bed of yellow sand. Mr. Crow has collected here the strombus pes pelecani, a murex, a species of cucullea, and several other bivalves.

One of the most interesting sections above the chalk is to be seen at Woolwich, near the banks of the Thames. At this place the junction of the chalk with the strata over it is plainly to be seen. Over the chalk is a stratum about 30 feet thick of very fine white sand; and towards the top there is a thin bed of clay. Next succeeds a stratum of about 10 or 12 feet, composed wholly of flint pebbles, which have been worn by water into their present forms, and lie in the utmost confusion piled on each other, having a vast number of fossil shells lodged in the interstices.

The whole has the appearance of having been at some period a heap washed up on the sea shore, similar to our modern beaches. The shells are entirely whitened, and having lost their animal matter, are extremely brittle: their species however may be in general ascertained, although very few are to be found entire. They have been already described by Mr. Parkinson.

The bottom of this stratum of pebbles is now about 30 feet above the level of the sea. Over this is a layer of sand with some ferruginous masses, and then several thin strata of clay alternating with sand. In this clay are vast numbers of bivalves, locked into each other so close that this must doubtless have been their original bed.

Other beds of sand succeed, and on the top there is a stratum of dark blue clay a few feet thick.

This bed, which is frequently referred to by Woodward in his history of fossils, has also excited the particular attention of Mr. Parkinson: but its fossils differ so much from those usually found in the London clay, that it is not easy to decide upon the place to which it ought to be referred; particularly since it is not even covered by a bed that can be identified with the London clay. Bivalves, resembling those of Woolwich, have been brought up in digging wells at other places on the banks of the Thames, but I am not aware that cerithia and the other fossils of this stratum have been so found. This bed is known to extend for a considerable distance on the south of the Thames, in the counties of Kent and Surrey. It is found at Bexley and Plumstead, at which latter place a thin stratum of minute fossil shells was laid open a few years ago, but which now appears to be lost.

At Bromley, which is not far above the chalk, vast quantities of oysters are found imbedded in a calcareous cement and forming, together with rounded pebbles, a sort of rock. It has been observed that these oysters are found adhering to the pebbles, indicating the formation of the latter previous to the growth of the former.

Woodward, in his catalogue, frequently mentions a bed of stone as occurring at Stifford in Essex, and containing fossil shells which agree with those at Woolwich and Bexley. In a late visit which I made to that part of the country for the purpose of ascertaining this fact, I was not fortunate enough to procure specimens of the rock. It is not indeed now to be seen where it is described by that author, being probably concealed by cultivated ground: but I learned that a stone did exist under the soil, which the labourers frequently came to in ditching, and I mention this in the hope that some one residing in that neighbourhood may examine into this matter.

It is said that thin strata of a calcareous rock are found in sinking wells through the London clay; but of this I have not seen any well authenticated specimens. The circumstance however is far from being improbable.

The extensive works now carrying on in the neighbourhood of the metropolis, as the cutting the hill at Highgate, the tunnel lately carried under the Thames at Rotherhithe, one under Hyde Park, the canal now forming in the Regent's Park, and several others of a similar kind, have thrown great light upon the nature of the London clay and its fossils, and furnish daily opportunities for observation highly useful to all those who are interested in the examination of our upper strata.

At Highgate-hill the beds consist of

1. Vegetable mould.
2. Several feet of loose gravel and highly ferruginous masses of sandstone.
3. Yellow clay.
4. Blue clay, in which great numbers of marine shells and parts of fish were found.

On the south side of the River Thames near Rotherhithe, a shaft sunk for a tunnel proposed to be carried under the Thames, exhibited the following strata.

Feet		
6	9	Vegetable mould.
9	0	Brown clay.
26	8	Gravel with water.
3	0	Blue clay.
5	1	Loam.
3	9	Blue clay with bivalve shells.
7	6	Gravel stones imbedded in a calcareous rock.
4	6	Light blue soil with pyrites.
1	9	Green sand.
8	4	Leafy clay.

The bottom of the shaft was 30 feet under the bed of the river Thames. The unfortunate failure of the project, from the river bursting in before they had completed a drift, is well known.

At Reading there are several pits dug for the purpose of procuring brick clay, some of which reach to the chalk; an account of the strata at this place is given us by Dr. Brewer in the Phil. Trans. 1800.

Immediately incumbent on the chalk is a stratum 2 feet thick of green sand containing numerous oyster shells. Many of these are entire, having both their valves united; but the animal matter being entirely gone, and the shell not having undergone the process of petrifaction, they are white and extremely brittle, and separate into laminæ. Fishes teeth are also found with them. Over this is a bed 3 feet thick of a bluish rough clay, then fuller's earth $2\frac{1}{2}$ feet, and fine white sand 7 feet. Next is a stiff red clay, probably the plastic clay, of which tiles are made. This is much thicker than any of the other beds; and over is the alluvial soil. These strata are known to extend for several miles with little variation.

At Brentford, on the borders of the Thames, about 6 miles from London, many important discoveries have been made in the grounds of Mr. Trimmer; an account of which has lately been read before the Royal Society. Here the chalk lies at a great depth, as they have dug 200 feet through the blue clay without coming to it. Immediately upon this clay are a few feet of sand and gravel with water; over that from 1 to 9 feet of calcareous loam; then sandy gravel 7 feet, and lastly calcareous loam or common brick earth 9 feet. In the blue clay were found the usual fossils of this stratum, being entirely marine. The three beds just over it contained a vast collection of the bones of elephants, both African and Indian, of the hippopotamus, the horns and jaws of oxen, the horns of deer, and both land and freshwater shells.

Richmond Park is on this stratum, and Woodward frequently refers to this place in his History of Fossils; but there are no longer any sections to be seen there, the spot being covered by buildings.

Wells of 70 feet deep have been dug at Harrow-on-the-hill; and several in London between 200 and 300 feet deep. At other places on rising grounds the depth of this stratum is much greater. In digging a well for Lord Spencer, at Wimbledon, they were obliged to go 530 feet deep before they got through it to the sand which contained water. At Primrose-hill, near Hampstead, a well was dug some years ago to the depth of 500 feet without success.

This considerable formation may not only be traced on the north side of Kent and Surrey, but almost the whole counties of Middlesex and Essex are composed of it. At South-end, and Leigh in Essex, there are good sections of it. But not having an opportunity of visiting the coast farther to the north, I am unable to speak with certainty respecting the various strata to be observed there.

The cliffs at Walton and Harwich, in Essex, have been best described. From various accounts the lowest part consists of blue clay, the fossils of which agree generally with those of Hordwell, Sheppey, &c. This clay is covered by deep beds of gravel, sand and marl, containing not only great quantities of fossil shells but also the remains of land animals.

From the confused manner in which these shells and pebbles lie, as described by Mr. Dale in his history of Harwich, there can be no doubt but that the strata containing them are frequently alluvial; though in the cases where he describes them as lying in patches of particular genera, we may suppose that portions of the original strata remain undisturbed.

Many of these latter fossil shells must belong to some of our latest strata: they are described as scarcely mineralized, very friable, and of a dead white colour.

The counties of Suffolk and Norfolk have been little explored, and still present a wide field for research. They will I have no doubt amply reward those members of the Society who have opportunities of examining them.

I shall now proceed to point out those particulars in which I have observed the marine formation which we have been examining to be analogous to some of the strata in the basin of Paris.

The plastic clay of the Paris basin is described as sometimes consisting of two beds separated by a bed of sand. The lower bed is properly the plastic clay. It is unctuous, tenacious, containing some siliceous but no calcareous matter; and absolutely refractory in the fire when it has not too great a portion of iron. It varies much in colour, being very white, grey, yellow, grey mixed with red, and almost pure red. This clay is employed, according to its quality, in making coarse or fine pottery and porcelain.

The corresponding beds of clay in this country agree well with this description. The clays of Dorsetshire are extremely pure, and are much employed in the potteries of Staffordshire and other parts of England. In Alum bay we see clays of all the colours just described. Some of them appear very promising, so much so that the late Mr. Wedgewood had pits opened there; but although extremely refractory, they were found upon trial not to burn sufficiently white for the purposes required. The deep red clays we have seen are very common in many parts of the country over the chalk.

No fossil shells have been found in this bed of clay in the French basin, nor in the clay pits of Dorsetshire; nor are there any in the pure clays of Alum bay.

The uppermost bed of potters' clay in France is sandy, blackish, and contains sometimes fossil shells of the genera cytherea and turritella, and the sand is often coloured red or bluish grey.

In the stratum of blue clay, next to the deep red clay that adjoins the chalk of Alum bay, there are septaria with fossil shells, among which I found cytheræ and turritellæ ; the rest were too much mutilated. Hence it would appear, that no fossil organic bodies are disseminated through the pure plastic clays of either basins, but that they are to be found in such beds of this clay as are impure.

A species of imperfect coal also occurs in the lower strata of the Paris basin, and is probably analogous to that of Corfe, Alum bay, and Newhaven.

The French sands are of a great variety of colours. The sands of Alum bay may correspond to that between their chalk and the plastic clay, which is described as very pure, though often coloured red or blueish grey. It is refractory, and often in very large grains.

In the lower marine formation of the Paris basin, the most remarkable and best characterized stratum is that of the coarse shelly limestone or calcaire grossier. This is generally separated from the chalk by the clay and the sand just described ; or, when that is wanting, it rests immediately upon the chalk. It is sometimes, also, separated from the clay by a bed of sand, more or less thick, in which no shells have been found.

The description given by the French of this calcareous formation is extremely precise, and corresponds to its importance. From this it appears to be composed of alternate beds of limestone, more or less hard, of argillaceous marl, of laminated clay, in very thin beds, and of calcareous marl. These are of great extent, and preserve constantly the same order of superposition, although all the beds are not continuous. Each bed is also characterized by its peculiar fossils. The lower are often more sandy than calcareous, and when solid they fall to pieces on exposure to the air. They frequently contain a considerable quantity of green earth, and this is found only in the lower beds, a circumstance which they have pointed out as particularly indicative of them.

The lowest bed is also particularly distinguished by the vast number of fossil shells contained in it; the greatest part of which are more unlike the recent shells than those of the superior beds. The fossil shells of this bed are often well preserved, and are easily detached from their matrix; and many of them have still their original pearly lustre.

The middle beds also inclose a great many shells; one of them is called the green bank, from its colour. It often contains impressions of leaves and stalks of land vegetables, mixed with cerithia, ampullariæ, and other marine fossils.

The next bed of calcaire grossier has less variety of fossil shells than those just mentioned, but the cerithia are very abundant in it: and towards the top there is a thin bed, containing a prodigious quantity of corbulæ, long shaped, and striated. Above these are the marls, both calcareous and argillaceous; with calcareous sand, sometimes agglutinated, and which contains hornstone with horizontal zones.

The uppermost beds of this system have much fewer shells; and these are generally altogether wanting at the top.

In passing over in review all the strata which we know above the chalk in England, there does not appear to be any one that can be considered as exactly corresponding to this considerable and well-marked stratum in the basin of Paris; and in instituting a comparison between the English and French strata, were we to require a perfect agreement in all the beds, we should here totally fail.

Yet although we cannot point out a calcareous rock precisely similar, and possessing the same importance of character, I think a sufficient number of circumstances may be shewn to justify our considering the greatest part of the materials of this formation as existing in the English basin, but differently modified.

For this purpose I shall consider the organic remains, which the French have observed to belong peculiarly to these beds, as very important.

The general correspondence between the fossil shells of Grignon and those of Hampshire, has been already pointed out by several able naturalists, and in particular lately by Mr. Parkinson. I should therefore scarcely have considered it necessary to state here what is already so well known, had I not been enabled during my late journey to the Isle of Wight, to add several not hitherto observed, and which bring the agreement still closer; and since organic remains furnish one of the best methods of identifying strata, or rather perhaps formations, it may at present be interesting to bring into one view the most characteristic fossils that have been observed in this formation in England.

The liberal assistance of Mr. Parkinson has enabled me not only to give the scientific names of Lamarck to the several fossil shells which I found, but also to add the corresponding Linnean names, by which they are chiefly known in this country. This however could not be done in every case, since many of the fossils of Lamarck were not known to former naturalists.

Organic remains in the Lower Marine formation above the Chalk in England.

Names given by Lamarck	*Linnean names.*	*Places where they have been found*
Astroitæ	Astroitæ	Sheppey
Calyptrea trochiformis	Trochus apertus, Brander	Hordwell, Bognor, Woolwich, Plumstead
Conus	Conus	Hordwell, Stubbington
Cyprea pediculus . .	Cyprea pediculus . .	Stubbington, Highgate
Terebellum convolutum	Bulla sopita, Brand. .	Hordwell
Oliva	Voluta	Alum-bay
Voluta spinosa . . .	Strombus spinosus . .	Alum-bay
——— musicalis . .	——— luctator . .	Hordwell
——— bicorona . .	——— ambiguus . .	Hordwell
——— crenulata . .	Murex suspensus . .	Hordwell, Alum-bay
	Voluta ampullaria . .	Brentford, Alum-bay
Buccinum undatum . .	. . . .	Alum-bay
Harpa	. . . .	Brentford
Cassis carinata . . .	Buccinum nodosum, Bran.	Stubbington, Highgate
Rostellaria macroptera	Strombus amplus . .	Hordwell, Highgate
Murex tripterus . . .	Murex tripterus . . .	Hordwell
——— tricarinatus . .	——— asper	Hordwell
——— tubifer . . .	——— pungens . . .	Hordwell
	——— contrarius . .	
	——— whirls the right way	
Fusus longævus . . .	——— longævus . .	Hordwell
——— clavellatus . .	——— deformis . . .	Hordwell
——— rugosus . . .	——— porrectus . .	Hordwell
Pyrula nexilis . . .	——— nexilis . . .	Hordwell
Pleurotoma ?	. . . .	Alum-bay
Cerithium gigantum .	Murex	Stubbington
Cerithium, another variety, but too mutilated to ascertain the species . .	Murex	Sheppey
Trochus agglutinans .	Trochus umbilicaris, Bran.	Stubbington, Hordwell
——— monilifer . .	——— nodulosus . .	Hordwell
Solarium caniculatum or	Turbo, tab. 1. fig. 7 & 8. Brander	Hordwell
Delphinula ?	Turbo, tab. 1. fig. 7. Brand.	Hordwell
Turritella terebellata .	Turbo terebra . .	Hordwell, Stubbington, Alum-bay, Selsea
——— imbricatoria .	——— editus . . .	
——— multisulcata .	——— vagus . . .	
Ampullaria patula . .	Helix mutabilis . .	Hordwell, Stubbington, Bognor

Names given by Lamarck	*Linnean names*	*Places where they have been found*
Dentalium elephantinum	Dentalium elephantium	Hordwell, Sussex
——— entalis . .	——— entalis . .	
——— dentalis . .	——— dentalis .	
——— striatulum .	——— striatulum .	
Serpula	Serpula	Hordwell, Bognor, Sheppey
Nautilus imperialis . .	. . . .	Sheppey, Highgate, Brentford
——— pompilius . .	. . . .	Sheppey, South-end, Highgate, Brentford
——— centralis . .	. . . .	Richmond
Lenticulina rotulata .	. . . .	Stubbington
Nummulites lævigata .	. . . .	Brackelsham in Selsea
Pinna, 2 species . . .	Pinna	Bognor
Mytilus modiola . . .	Mytilus	Bognor, Highgate
Pectunculus pulvinatus	Arca glycemeris . .	Bognor, Stubbington, Essex
	—— noæ	Stubbington
Cardium porulosum .	Cardium porulosum	Hordwell
——— asperulum .	——— asperulum .	
——— obliquum . .	——— obliquum .	
Crassatellata lamellosa .	Tellina sulcata . . .	Hordwell
Venericardia planicosta	. . . .	Stubbington, Selsea
Capsa rugosa	Venus deflorata . . .	Pagham
Chama lamellosa . .	Chama squamosa . .	Hordwell
——— calcarata . . .	. . . .	Hordwell
——— sulcata . . .	. . . .	Hordwell, Stubbington, Alum-bay
Ostrea edulis	Ostrea edulis	Bognor, Selsea, Essex
Pyrus bulbiformis . .	. . . .	Hordwell, Stubbington, Alum-bay
Caryophillia	Turbinated Madrepores	Sheppey
Teredo navalis . . .	Teredo navalis . .	Stubbington, Portsmouth, Sheppey, Bognor, Highgate
Jaw of a Crocodile . .	. . . .	Sheppey
Testudo or Turtle . .	. . . .	Sheppey
Various Fish, but too mutilated to ascertain the species . . .	. . . .	Sheppey
Fish teeth, supposed by some to belong to the shark	. . . .	Sheppey, Stubbington, Highgate
Molar teeth of fish, called Bufonites .	. . . .	Sheppey
Palatum Scopuli and other palates of fish	. . . .	Selsea, Sheppey

Names given by Lamarck	*Linnean names*	*Places where they have been found*
Tongue of a fish of the genus Raia . . .	. . . .	Sheppey
Tail of the Sting Ray .	. . . .	Highgate
Scales of fish	. . . .	Sheppey
Vertebræ of various species of fish . .	. . . .	Sussex, Sheppey, Highgate
Cancer, above 20 species of Crabs .	. . . .	Sheppey
—— Gammarus or Lobster .	. . . .	Sheppey
—— Crangon or Prawn . .	. . . .	Sheppey
Wood, often pierced by the Teredo navalis & filled with pyrites or calcareous spar .	. . . .	Portsmouth, Sheppey, Highgate
Fruits, branches, excrescences, ligneous seed vessels and berries impregnated with pyrites	. . . .	Sheppey, Emsworth in Sussex

Although nearly 600 species of fossil shells have been described by M. Lamarck as belonging to the calcaire grossier, Messrs. Cuvier and Brongniart have selected the following as particularly characteristic of the several beds.

Lower beds.

Nummulites lævigata	Cerithium giganteum
——— scabra	Lucina lamellosa
——— numismalis	Cardium porulosum
——— &c.	Voluta cithara
Madrepora	Crassatella lamellosa
Astræa	Turitella multisulcata
Caryophyllia	Ostrea Flabellula
Fungites	——— Cymbula

Middle beds.

Cardita avicularia	Citheræa nitidula
Orbitolites plana	——— elegans
Turritella imbricata	Miliolites
Terebellum convolutum	Cerithium?
Calyptræa trochiformis	Articulated bodies
Pectunculus pulvinatus	resembling vegetables

Upper beds.

Miliolites	Cerithium lapidum
Cardium lima or obliquum	——— petricolum
Lucina saxorum	Corbula anatina?
Ampullaria spirata	——— striata
Cerithium tuberculatum	Impressions of leaves
——— mutabile	

Messrs. Cuvier and Brongniart remark that the nummulites are found only in the lowest beds of the calcaire grossier, to which belongs also the cerithium giganteum. I am enabled by the information of Mr. Holloway, who pointed out to me these fossils at Bracklesham in Selsea, and also in Stubbington cliff near Portsmouth, to add this very strong circumstance of agreement with the French strata.

It is impossible not to be struck with the identity of the fossil shells of the sandy beds of Liancourt with those of Stubbington.

At the former of these places are found:

Nummulites lenticularia
——— lævigata
Turritella terebellata
——— imbricataria
Crassatella sulcata
Venericardia planicosta
Sharks' teeth

The whole of which are to be found at Stubbington.

These beds of Liancourt contain also masses of sandy limestone filled with chlorite: and Stubbington is remarkable for the quantity of green earth which it contains.

A circumstance is mentioned by the French authors which appears to point out a remarkable era in the history of these strata. They observe, that in the beds of the lower marine formation, and particularly in those of Liancourt, natural wells of considerable size are sometimes found, filled with ferruginous and sandy clay and water-worn siliceous pebbles. These wells do not pierce through all the beds of the calcaire grossier; but begin at the same level, and are covered and closed by the uppermost beds: shewing that they were formed after the period of the formation of the lowest, and before that of the upper beds; which points out a very long interval, and the action of violent causes during this time.

It may be remarked, that this is exactly the period to which we must look for the subversion of the strata of the Isle of Wight, and the formation of its basin. If therefore the deposition of the upper beds of the calcaire grossier was general, and extended to this part of the globe, it must be placed at the lowest part of the Isle of Wight basin, and probably therefore at an inaccessible depth.

The rocks of Bognor and Selsea appear to be the most easily referable to some of the beds of the calcaire grossier of France. The correspondence in their geognostic situation, in the nature of their materials, and in the fossils which they contain, sufficiently justify the supposition.

Although in general the beds of the calcaire grossier maintain a regularity remarkable and distinctly to be traced, yet that is not always the case, the quarries of Saillancourt being cited as an exception to this rule: all the beds are there united, and nearly of the same quality, which appears to be owing to calcareous spar cementing the parts together. In our blue clay there is a considerable quantity of carbonat of lime in a sparry state, as is evident from the septaria.

The middle and upper beds of the French calcaire grossier frequently contain a sandstone, with marine shells which agree, though not entirely, with those of the calcaire. This sandstone is sometimes white and friable, and sometimes shining and almost translucent. The shells are frequently white, calcareous, and well preserved, though sometimes broken and mixed with pebbles.

The sandstone which forms the uppermost beds of the rocks of Bognor, already described, do not differ much from this description. It contains some fossil shells of the same species, though not in such numbers as the lower beds; and some of those in the lower beds, as the pinnæ, are not met with in the upper beds; the shells also are frequently whitened.

By connecting all the above circumstances it would appear, that if we could suppose a blending or mixture between the French plastic clay, which is blackish and contains organic bodies, and the lower beds of the calcaire grossier with its green earth and fossils, we should have a compound agreeing sufficiently near with our London clay under all its varieties; with this difference, that that of the French basin would have a greater proportion of calcareous, and ours of argillaceous matter. We may therefore fairly infer that they belong to the same epoch. But with respect to the upper beds of the calcaire grossier of France, no strata have yet been discovered in this country that correspond to them. Whether any such ever existed, and whether any traces yet remain, may perhaps prove a fit subject for future enquiry.

§ 3. *Lower Freshwater Formation.*

This formation is to be seen most distinctly in the section of the hill called Headen, which forms the northern boundary of Alum bay, in the Isle of Wight. It appears there in a series of beds of sandy calcareous and argillaceous marls; sometimes with more or less of a brownish coaly matter. Some of them appear to consist almost wholly of the fragments of freshwater shells, many of which are however sufficiently entire to ascertain their species. These are the lymneus, planorbis and cyclostoma, and perhaps the helix; with a bivalve resembling the freshwater mytilus.

These beds lie immediately upon the black clay that covers the white sand, described in the account of Alum bay. They are extremely irregular, and are not to be traced distinctly from each other for more than about a few hundred yards, the remaining part being so hid by the mouldering slope, that the formation can only be observed in mass. It may be seen however extending round the north side of Headen into Totland bay, where it forms the upper part of the cliff: and at the point called Warden-ledge, it is found in a more uniform and indurated state. Here, when the clay upon which it rests gives way from the rain and frost, large masses of it fall down, which are employed for the purposes of building, though the stone is not of a good quality. Pursuing it farther into Colwell bay, it dips to the north, and is soon lost; nor is it to be seen any more on that side of Yarmouth. At the bottom of these beds, and between them and the black clay, there is frequently a layer of two inches or more in thickness of a dark brown coaly matter, much like what is usually found at the bottom of peat bogs, and it appears to be a similar substance that tinges many of the beds.

On a careful examination I was not able to discover any mixture of marine shells in this series of beds. Had they ever existed I think their remains would have been evident, considering how much thicker and stronger marine shells in general are than those of freshwater.

The quantity of shells, and the regularity and extent of the strata in which they are found, are much too considerable to suppose that they could have been carried by rivers or streams into an arm of the sea; and in this case there would also most probably have been a considerable intermixture of marine shells. We are compelled therefore to admit that the spot where they now are, was once occupied by freshwater, in which these animals existed in a living state.

The mutilated condition in which these shells appear, seems to denote that they had not become mineralized sufficiently to preserve their forms, or that the place in which they were accumulated was occasionally subject to agitations.

Freshwater strata occur occasionally in other parts of the west and north coasts of the Isle of Wight, but in such an irregular manner that it is not easy to say to what formation they belong.

Among those at Cowes and Ride there are none that I can completely identify with these beds. But I am at present inclined to think that the same formation exists at these places, though under a character considerably different.

The quarries of Binstead, near Ride, were formerly of great celebrity, and furnished the materials for many ancient edifices, both civil and religious, in the Isle of Wight and the counties contiguous to it. They are now very little worked; but their extent may be traced by the broken ground where they have been filled in.

The section of the strata is as follows, beginning at the bottom.

	Feet.	
1.—Blue clay	depth unknown	
2.—Sand	50	0
3.—A Siliceous limestone called rag	0	6
4.—Sand	0	8
5.—Siliceous limestone	0	6
6.—White shell-marl	0	10
7.—Siliceous limestone	1	6
8.—Limestone composed of the fragments of freshwater shells .	1	6
9.—Ditto, the fragments more apparent	2	0
10.—Ditto, the fragments still larger	4	0
11.—Ditto, fragments still coarser	2	0
12.—Blue Clay, in which are many large and loose masses which appear to belong to the upper Freshwater formation.		

At East Cowes Lord Henry Seymour had the goodness to point out to me a quarry which he had caused to be opened in his grounds, the strata of which were almost exactly the same as those of Binstead. The rag from this quarry his Lordship had employed in the construction of his mansion; and also in the fine wall which he has built to keep off the encroachments of the sea.

In the strata of East Cowes the casts of the shells are frequently entire, and appear to belong to the genus Cyclostoma Lam.

The fragment stone of Binstead, when examined with a magnifier, has a very singular appearance. In some specimens the fragments themselves remain, though in a sparry state; but in general the substance of the shell has disappeared, leaving a cavity where it formerly existed; so that in fact, instead of being fragments cemented together by calcareous spar, the stone consists of the hollow moulds of fragments held together by that matter. It would seem as if the shells themselves had been gradually absorbed into the substance of the cement.

The whole of the north shore of the Isle of Wight has been for ages in a state of constant ruin by the action of the sea and the sliding down of the soil. It is difficult therefore to find any part of the strata in their original situation; on this account freshwater and marine shells are frequently found together in confusion. I have however observed some places where they occur in alternate layers.*

The cerithia, cyclades, cytheræa, oysters, and other fossil shells, which are so numerous on the shore near Cowes, are derived from the blue clay of the upper marine formation, which is situated above that which we are now considering, and of which the sloping banks chiefly consist.

That occasional alternations and mixture of marine and freshwater shells should occur, may, a priori, be expected. They would denote either the gradual nature of the change that has taken place in an arm of the sea before it became completely a lake of freshwater, or the occasional irruptions of the ocean at a subsequent period.

These beds may be traced a considerable way eastward of Ride, and I believe as far as Nettlestone, but I have not had an opportunity of ascertaining their precise boundaries. Neither have I been able to learn with certainty that any part of this formation is to be found on the coasts of Hampshire on the opposite side of the Solent; and I do not find it eastward on the Sussex side.

Woodward, however, in his valuable catalogue of fossils, frequently makes mention of freshwater shells in a marly stone from

* The only shells which I noticed thus alternating with those of freshwater, appeared to belong to the genus Cerithium, but not having specimens of them it has since occurred to me, and it will deserve future observation, whether these were not the Potamides Lamarkii. They are abundant at Gurnet Point.

the Hordwell cliffs. It is very probable therefore that traces of this formation may be found there, if this spot were well examined for the purpose.*

Land and river shells have been repeatedly discovered in various parts of England; and often at some depth under beds of sand and gravel. They are then often accompanied by the bones of land animals as those of the elephant, hippopotamus, &c. and may be referred to a very ancient period probably connected with some of these formations. None of them however had as yet been discovered imbedded in a stratum of rock. When they have been found under peat bogs they have been most probably produced in some of the later states of the earth.

It is in this formation, in the Paris basin, that the gypsum beds are placed. Three series of gypseous strata are described: the lowermost consists of thin beds of gypsum, often selenitous, of solid calcareous marls, and foliated argillaceous marls; and they observe, that these are sometimes deposited on the marine shelly calcareous sand, and then they contain marine shells. In these are also beds of white marl, containing a great quantity of freshwater shells of the genera limneus and planorbis. These lower beds, with the white marl, constitute the oldest freshwater formation; and, according to the observations of M. M. Cuvier and Brongniart, appear to have been formed during the passage or change of the Paris basin from the state of a marine bay to that of a freshwater lake. The second mass of beds differs from the above mentioned

* Since the reading of this paper I have been favoured by the Rev. William Buckland, Prof. of Mineralogy, Oxford, with specimens of freshwater shells which he has collected at Hordwell cliff. They consist of the lymneus, planorbis, cyclostoma, and a bivalve resembling a freshwater mytilus. From the state of the fossils, and the nature of the stratum in which they were imbedded, they would appear to belong to the lower freshwater formation.

in the gypsum being thicker, and in the occurrence of a bed of very indurated clay containing fossil fish. The third or uppermost mass is the most important, the beds of gypsum being very thick; it is here alone that the bones of unknown birds and quadrupeds are met with. Freshwater shells are also found in it, though rarely.

Over the gypsum are very thick beds of calcareous and argillaceous marls; one of the latter, which is white and friable, contains silicified trunks of palm trees, and in the former are found many freshwater shells. In this freshwater formation are found neither the meulieres, nor any other flints, except the silex menilites, and the hornstone of the upper gypsum beds.

The total absence of beds of gypsum and of the remains of quadrupeds, in this formation in the Isle of Wight, (at least as far as my observations extend) exhibits a striking proof, that although probably of contemporaneous origin, yet the circumstances accompanying its formation were very different from those under which that of the basin of Paris was produced. The gypsums of Montmartre are well known; and they are considerably different in their appearance from those of England, which belong only to strata far below the chalk. It has been already observed, that selenite is very abundant in our blue clay; but this arises from the decomposition of the pyrites contained in it.

§ 4. *Upper Marine Formation.*

Over the lower freshwater formation in the Isle of Wight, a stratum occurs, consisting of clay and marl, which contains a vast number of fossil shells wholly marine. Few of these shells agree with the species that have been found in the London clay, and they are also considerably different from them in their state of preservation; most of them appearing to have undergone but little change, and some are even scarcely to be distinguished from recent shells. The situation of this bed, distinctly placed above the vestiges of a freshwater lake, would seem to indicate some great revolution in the relative level of the land and sea, since the time of the marine deposit which we have already considered; and the above circumstances, combined with its position as regards the vertical beds of Alum bay, point out in strong characters a later period.

The spot where this stratum is best examined is Headen, near Alum bay. It there appears half way up the cliff; is about 36 feet thick, and dips a few degrees to the north. It passes from thence all round Totland and Colwell bays.

The substance of the stratum is chiefly marl of a light greenish colour, and the fossil shells are so numerous that they may frequently be gathered by handfulls, and are in general extremely perfect. I did not observe that the several species occupied separate beds, although they were much thicker together in some places than in others, and were then oftener accompanied by rounded nodules of greenish indurated marl. From the delicacy of the shells and their perfect preservation, it is evident that they could not have been brought from great distances, but must have lived near to the spots where they are now found. This greenish marl is separated from the upper freshwater formation only by a bed of sand a few inches in thickness.

In Colwell bay, at a fissure called Bramble's chine, there is in this stratum a very large bank of fossil oyster shells; the greater part of which are locked into each other in the way in which they usually live, and many have their valves united. It is therefore clear that this oyster bed has never suffered a removal.

This stratum may be traced, with various interruptions, all round the north side of the Isle of Wight, and may be seen at Cowes, Ride, and Bembridge.

In the enumeration of the various strata in the basin of Paris, our attention is particularly called to a thin bed of bivalve shells covering the upper beds of gypsum and gypseous marls of the lower freshwater formation, the shells of which are placed close, and as it were locked into each other. This bed, though apparently of little importance, is remarkable by its great extent; having been observed over a space of more than 10 leagues in length, and more than 4 in breadth, and always retaining the same situation and thickness. It is still farther distinguished as marking out the beginning of the new series of strata deposited by the sea.

Over this thin bed of bivalves there is one of greenish marl without fossils; and then several alternating beds of argillaceous and other marls and sands, containing marine fossils, shells, and bones of fish. Two beds of oysters are particularly noticed; and it is observed that these must have lived upon the spot where they now are, because they are locked into each other as in their natural beds, with many of their hinges entire. The uppermost beds of marls are however not constant; sometimes, as at Chellis, there is only a thin bed of sand between the green marl and the upper freshwater formation. It is in these marls that the silex menilite is found.

The changes which the surface of the earth has experienced have no doubt destroyed so much of the last depositions in the London as well as in the Isle of Wight basins, that it is impossible to say what the complete series was originally.

Of the existence of this upper marine formation therefore in the London basin, I must speak with diffidence, more particularly since an extensive freshwater formation might never have existed there, and consequently the last marine deposits would be placed immediately upon the lower ones, and would be less easily distinguished, as is frequently the case in the basin of Paris, where we are informed that the sandstone without shells, which is over the marls belonging to this formation, is placed immediately upon the siliceous limestone of the lower marine formation, on the heights to the east of Melun and of Samoineau; the gypsum being wanting there. But as it forms the summits of almost all the hills and plateaux where the gypsum beds are found, they form a separation between the upper and lower marine strata, and render their distinction no longer uncertain. In the counties of Suffolk and Norfolk, there are very extensive beds of marine shells, imbedded chiefly in a ferruginous sand, and lying above the London clay, which have been described under the name of *Crag pits*. Among the fossils which have been enumerated as belonging to these beds, many agree with those in the upper marine formation in the Paris basin, and others do not appear to differ from the recent shells of the neighbouring seas.

Fossil shells agreeing with the recent occur also in many other parts of the kingdom, now considerably removed from the sea, and are often buried under beds of gravel. These probably belong to the last states of the earth, and might serve as a clue to unravel geological mysteries.

If we depend upon fossils as a principal means of identifying strata, we shall see great reason to believe that the last of our marine depositions are nearly allied to the upper marine formation of the basin of Paris.

In this stratum in the Isle of Wight I found the following fossils.

Names given by Lamarck.	*Linnean Names.*
Cerithium plicatum	Murices
- - - lapidum	Murices
- - - mutabile	Murices
- - - semicoronatum	Murices
- - - cinctum	Murices
- - - turritellatum	Murices
- - - tricarinatum	Murices
Cyclas deltoidea	Venus
Cytherea scutellaria . . .	Venus
Ancilla buccinoides . . .	Voluta
- - subulata	Voluta
Ampullaria spirata . .	Helices
- - - depressa? . .	Helices
Murex reticulatus	
Bivalve apparently of the genus Erycina	
Helicina?	
Murex nodularius	
Melania? They are however too much injured about the mouth to determine their genus with certainty	
Another species of Melania corresponding to those of Plumstead	
Natica Canrena . . .	Nerita
Ostrea, approaching to deltoidea	
- - - specific characters not evident, but different from the last	

Fossils found at Harwich in Essex.

Names given by Lamarck.	*Linnean Names.*
	Patella ungaria
	- - - lævis
Patella spirorostris	- - - fusca
Fissurella labiata . . .	Patella
- - - emarginula . .	- - - fissura
Calyptrea sinensis . . .	- - - sinensis
Eburna glabrata . . .	Buccinum glabratum
- - -	Murex corneus
- - -	- - - erinaceus
- - -	- - - contrarius
- - -	Trochus sulcatus
- - -	- - - - alligatus
Ampullaria rugosa	
Natica canrena	
- - glaucina	
Mactra	
Venericardia senilis . . .	Arca senilis
Lucina	Venus gallina
- - -	Solen siliqua
Pholas crispata	
- - - - - - -	Ostrea deformis
Pecten plebeius	
- - - infirmatus	
Balanus	

Some of these however may belong to the lower marine blue clay.

M. Brongniart mentions the following as being found in the *various beds of the upper marine marls.*

Cytherea *(bom-bees)*	Ostrea Hippopus
- - - plana	- - Pseudochama
- - - elegans	- - longirostris
- - - semisulcata	- - canalis
Cerithium plicatum	- - cochlearia
- - - cinctum	- - cyathella
Ampullaria patula	- - spatulata
Cardium obliquum	- - linguatula
Nucula margaritacea	Bones and parts of Fishes
Patella spirorostris—Cuv. p. 187.	

In the upper marine sand stones.

Oliva mitreola	Pectunculus pulvinatus
Fusus, resembling longævus	Crassatella compressa ?
Cerithium cristatum	Donax retusa ?
- - - lamellosum	Cytherea nitidula
- - - mutabile ?	- - - lævigata
Solarium ?	- - - elegans ?
Melania costellata ?	Corbula rugosa
Melania ?	Ostrea flabellula

I have already mentioned that considerable difficulties appear to me to exist in assigning a place to the Woolwich beds. The actual lowness of their level, *appearing* to dip under the London clay, and their situation near the chalk without the intervention of that bed, at first seem to determine their geognostic position. Whilst the circumstances of their not being seen in any part covered by the London clay, nor having been actually identified with any strata which have been found in sinking through it with certainty, leave the question still undetermined; and the agreement of the fossils of the Woolwich and Plumstead beds with those of the upper marine formation in the Isle of Wight, not only in their species but in their state of preservation, is sufficiently striking to suggest the idea of a similarity in the circumstances of their production.

The considerably greater elevation of Highgate-hill, and of other places known to consist of the London clay, above the Woolwich beds, is scarcely of itself a satisfactory reason for supposing that the latter exist under the former, since the changes to which this part from the chalk upwards has been subjected at various periods, are sufficiently pointed out by the extensive banks of pebbles of very ancient date, and the other proofs of the agency of water. The great irregularity in the surface of the chalk stratum is obvious from its disappearing so suddenly on the north bank of the Thames; and it is not difficult to imagine that from currents and other local causes, the deposition of the London clay might not have taken place in certain spots, which might yet have been covered by the sea that gave rise to the upper marine stratum on the Isle of Wight. It must be confessed however, that for want of proper sections, we have not yet sufficient data for determining this point with accuracy, and I shall content myself at present with having described such facts as I have myself noticed, leaving this subject to future investigation.

Mr. Parkinson enumerates the following as found at Woolwich.

Names given by Lamarck.	*Linnean Names.*
Cerithium turritellatum	Murices
- - - denticulatum	
- - - serratum	
- - - claviculatum	
- - - mutabile	
- - - cinctum	
- - - semicoronatum	
Cytherea scutellaria	Venus
Cyclas deltoidea	
Calyptrea trochiformis	Trochus apertus
to which I have added	
Ancilla Buccinoides	Voluta

At Plumstead.

Melania	Helix
Arca	Arca
Ampullaria	Helix
Calyptrea trochiformis	
Cyclas	
and Mr. Parkinson has since found	
Nucula margaritacea	Arca nucleus
Teeth of fishes	

At Newhaven.

Cerithium denticulatum	Murex
Cytherea scutellaria	Venus
Ostrea	Ostrea

In the Paris basin the marine marls are covered by a very extensive and thick bed of sand, entirely without animal exuviæ, which has nearly filled up all the cavities which still existed on the surface of the basin, covering the partial formations of marine gypsums, the lower freshwater marls, together with all the other strata, and reducing the surface nearly to a level.

This sand frequently contains beds of sandstone of the same nature with itself, which frequently form the flanks of the hills in the neighbourhood of Paris; and great blocks of these have frequently rolled down into the valleys, the sand having been carried away; such are the sandstones in the forest of Fontainebleau, Palaiseau, &c. The sand of this stratum is often an extremely pure white quartz, and is much used in the arts; but sometimes it is coloured by oxides of iron, or impregnated by carbonat of lime. It forms all the soil of Beauce. The sandstone is very hard, pure, and homogeneous.

This bed is usually covered only by the burr stones without shells, or by the upper freshwater formation. Over it however there is in some parts a sandstone containing marine shells, agreeing nearly with those of the middle beds of the calcaire grossier, or rather with those already observed in this upper marine formation; and in other places a calcareous stratum with shells.

The London clay is in many places covered by an extensive bed of sand, usually called the *Bagshot sand*. It extends over Bagshot, Frimby, and Purbright heaths, in the county of Surrey, and that on Hampstead heath belongs also to it.

At Purbright, and many parts of the surrounding country, loose blocks of a stone is found similar to what has been called the *grey weathers*. This stone, composed of siliceous particles cemented together without any intervening substance, may be considered as a granular quartz. It has more the appearance of an original formation, or peculiar crystallization of siliceous matter analogous to that of sugar, than to a substance composed of the detritus of other rocks.

Numerous large and loose masses of this rock lie scattered over the surface of the chalk country, particularly in Berkshire and Wiltshire, but a bed or continuous stratum of it has not yet been observed. These stones were much employed by our ancestors in building, and before the ground was cleared for the purposes of agriculture they were much more numerous than at present. The huge erections of Stonehenge, which have so much exercised the conjectures of our antiquaries, are chiefly* composed of it, and the blocks were no doubt found on the spot.

This granular quartz bears a close resemblance to the siliceous cement of the *Hertfordshire pudding-stone*, which also is often found in loose masses above the London clay. There appears no necessary connexion between the pebbles of this beautiful conglomerate and their cement, but the dates of their origins were very different; the siliceous deposition, when it did not envelope any foreign substance, forming the rock called the grey weathers; and when it fell among pebbles of any kind, composing a pudding-stone. Accordingly we sometimes find in the grey weathers common chalk flints.*

* It is not a little singular that some of the smaller upright stones of Stonehenge consist of a sort of *greenstone*, and must therefore have been brought from a very great distance, no such rock occurring in the neighbourhood.

† Specimens of these collected in the neighbourhood of High Wycombe, by the Hon. Henry Grey Bennett, Pres. G. S. are deposited in the Museum of the Society.

§ 5. *Upper Freshwater Formation.*

I have now to describe the most remarkable and best characterized of all the strata in that hill in the Isle of Wight called Headen, which has so frequently come under our examination.

Here, immediately over the last-mentioned formation, there is a thin bed of sand of 6 inches, upon which rests immediately a very extensive calcareous stratum 55 feet in thickness, every part of which contains freshwater shells in great abundance, without any admixture whatever of marine exuviæ.

The substance of which this stratum consists is of various character, although it cannot be described as being subdivided into smaller beds. A great part is composed of a yellowish white marl, sufficiently indurated to remain in blocks when fallen down, but extremely friable, and which, like other marls, will not endure the frost. In this, and disposed without any regularity, are hard masses of a rock which appears to contain a greater proportion of calcareous matter; and to be in about an equal quantity with the marl. This stone is very durable, and is employed as a building material. Between these two extremes there are many parts of intermediate degrees of hardness and durability.

Many of the shells which are found imbedded in this stratum are quite entire, and these are mixed with numerous fragments of the same species. They consist, like the lower freshwater formation, of several kinds of lymnei, helices, and planorbes, and from the perfect state of preservation in which they are found, must evidently have lived in the very spots where they now are, the shells of these animals being so friable that they could not have admitted of removal from their original situations without being broken.

These organic remains therefore most distinctly mark the nature of the place where the strata enveloping them have been deposited. It must unquestionably have been the bosom of an extensive lake in some period of the earth far antecedent to human history; nor can we refrain from emotions of extreme astonishment when this conviction is forced upon us, nor help indulging in speculations on the revolutions which the earth must have undergone, when we consider how very differently these strata are now situated. Instead of being found in a hollow, they now compose the upper part of a hill; nor are they any more surrounded by those elevations which must have been essential to the confinement of the vast body of fresh water which furnished a habitation to myriads of animated beings, and of which we have nothing to demonstrate the former existence, except the nature of its depositions, which remain a faithful record.

Over this bed is a stratum of clay 11 feet in thickness, containing numerous fragments of a small bivalve shell. The hinge of this shell is of so peculiar a structure that Mr. Parkinson was not able to refer it to any known genus. The shells are thin, and unmixed with any other species whatever. It is impossible therefore to say whether they have belonged to marine or freshwater animals, and I have preferred for the present to keep them among the latter, rather than to suppose another alternation of which there is no direct proof.

Upon this lies another bed of yellow clay without shells, and then a stratum of friable calcareous sandstone, also without shells.

To this sandstone succeed other calcareous strata having a few freshwater shells. In these, which, like those mentioned above, are not subdivided into distinct beds, are parts of extreme compactness, so as to acquire a porcellanous character. Other parts contain masses of loose chalky matter, most of which are of a roundish form; and among these also are many beds of a calcareous matter, extremely dense, and much resembling those incrustations that have been formed by deposition from water on the walls of ancient buildings in Italy.

Through all these last strata are veins, frequently several inches in thickness, of very pure carbonate of lime, which is crystallized, frequently in a radiated form.

This stratum may be seen in many parts of the Isle of Wight, north of the middle range of chalk hills. On the western coast it does not extend farther than Totland bay, but occurs again at Warden point, forming the summit of the cliff.

Numerous blocks of it lie loose in the soil in many parts about Cowes, Binstead, and Bembridge. But in the neighbourhood of Calbourne, and between that place and Thorley, several quarries are opened in it, and afford an excellent stone. The fossil shells are here larger than I have observed them in any other part, the planorbes being full two inches in diameter, and the cyclostomæ nearly as large. The rocks at Bembridge ledge and Whitecliff bay, on the east side of the island, must also be referred to this formation.

It appears therefore to have originally extended over the whole of the northern half of the island; but I have not yet been able to find it on this side of the water, and it is still uncertain whether it ever existed here, or whether it has disappeared amidst the last revolutions to which the surface of the earth has been subjected.

This formation may be considered as the latest in this country which we have as yet been able to detect: and of all those above described it agrees most nearly with its corresponding formation in the Paris basin, with this difference however, that none of ours is siliceous; I shall therefore, in the succeeding comparison, confine myself to the calcareous part.

The external characters of this in both countries are sufficiently different from every other known rock to render them distinguishable even without the shells. That of France is described as white, or yellowish; sometimes as tender and friable as chalk or marl, and sometimes very hard, compact and solid, with a fine grain and conchoidal fracture. In the latter case it breaks into sharp fragments like flint, and cannot be worked as stone; sometimes it will even admit of being polished as marble. It is also frequently filled with infiltrations of calcareous spar.

This description corresponds very nearly with the freshwater rock of the Isle of Wight, and an examination of the specimens from both places leaves no room to doubt of the similarity of the strata.

The fossil shells which I found in the upper freshwater formation, and which have been described by Mr. Parkinson, are the following.

Names given by Lamarck.	*Linnean names.*
Planorbis, much resembling that which Brongniart says approaches to P. cornu Planorbis, two other species Planorbis, much resembling P. prevostinus	Helix planorbis
Ampullaria - - - - - - - - - -	Helix
Cyclostoma - - - - - - - - - -	Helix
Limneus longiscatus - - - - - - -	Helix stagnalis
- - - - acuminatus	

Limneus corneus
perhaps a large specimen of L.
longiscatus
Gyrogonites
Striated seeds of a flattened oval form, with
parts of coleopterous insects.*

M. Brongniart has enumerated the following fossils as belonging to this formation.

Cyclostoma elegans antiquum	Limneus inflatus
Potamides Lamarckii†	Bulimus pygmeus
Planorbis rotundatus	- - terebra
- - cornu	Pupa Defrancii
- - prevostinus	Helix lemani
Limneus corneus	- Desmarestina
- - fabulum	Gyrogonites
- - ventricosus	

The last mentioned fossil, to which Lamarck has given the name of Gyrogonites, is a small globular canellated body about the size of a mustard seed. The specimens of the French fossils of this species, in the possession of the Society, are extremely perfect, and correspond exactly to those which I found. They are very numerous in the freshwater stone at Gurnet point; but they are there

* These were found in some specimens of clay containing also freshwater shells which were dug out of a deep well at Newport. But as no distinct account was kept of the strata passed through, it is not certain to which of the freshwater formations they belong.

† It is proper to observe that the Potamides of Lamarck is a Cerithium. But having considered the cerithia as marine shells, he thought it proper, on finding a species among the freshwater shells, to regard this as of a distinct genus; founding the distinction not on any difference in its form, but on the difference of the water in which it had lived.

only to be seen as casts. In the numerous portions of a thin calcareous bed of a highly crystalline structure which lie scattered on the shore at Cowes, (but which I have not been able to find in situ) these Gyrogonites are found mixed with cerithia, bivalves, and a species of serpula ; all these shells being in a whitened state. This fossil was formerly placed by the French naturalists among the multilocular shells, but from a late number of the Journal de Physique, it appears that recent observations have shown it to be the petrified seed of a species of chara.

It is singular that the Calcaire d'eau douce of the basins of Paris and of the Isle of Wight, though found so abundantly in both countries and constantly used as a building material, should have so long escaped the observation of naturalists. At the latter place it has been employed for building from time immemorial, not only in that island but in many places on this side of the channel, as at Portsmouth, Southampton, Lymington, &c.

§ 6. *Alluvium.*

Under this title may be comprehended all those collections of various materials, which have been transported at some former period from different parts of the globe, and deposited on the surface.

The whole of it is evidently composed of the detritus or fragments of substances which have been originally formed into regular strata, but which have been torn up and confusedly mixed together by violent and extraordinary causes, or gradually accumulated by rivers or meteoric agents. It is therefore, as might be expected, extremely various, according to the nature of the strata from which it has been derived.

Considered in this point of view the study of it becomes particularly interesting, since it enables us to trace back, in some degree, the great changes which have taken place upon the surface of the earth.

In that part of our island which we are now considering, this alluvium or covering is of a nature peculiar to it. Besides the vegetable earth, clays, marls, and sands, which it possesses in common with other places, it is distinguished by a vast quantity of rounded siliceous pebbles of various kinds and sizes, which lie distributed in a very unequal manner, sometimes forming thick beds intermingled with clay, sand, and small sharp fragments of flints, at other places mixed with shells of various kinds, and sometimes almost without any other substance. This compound is termed *Flint gravel.*

When we observe a heap of these pebbles, we easily see that they consist of a great variety of kinds, and upon attentively examining them we are able to reduce this variety to several classes.

Some are evidently fragments of the flinty nodules originally belonging to the chalk strata. This is evinced by their mineralogical characters, their sharp conchoidal fracture, peculiar black colour, and by portions of the white crusts with which they were invested while in the chalk beds still remaining attached to them.

In others this origin is not so evident, the crusts having been entirely worn off, and the fragments themselves rounded by attrition. Yet their fracture, colour, and other circumstances, oblige us to suppose that these also were derived from the chalk. In many places the whole or the greater part of the gravel consists of these rounded chalk flints; and hence probably some have been induced to suppose that all the pebbles of the London gravel have proceeded from the same source.

But besides these other siliceous nodules occur, the origin of which is not so evident, as they differ in many respects from the chalk flints in their usual state. Of these some are of a deep red colour with a great degree of transparency resembling carnelian: others are of a yellow calcedony often translucent and even botryoidal, and they pass into a kind that is yellow, opake, and of a waxy lustre. Others again appear to be nearly allied to hornstone, and are frequently of irregular shapes, which are probably those of the original nodules.

Another remarkable class of siliceous pebbles is found either mixed with all those above mentioned, or alone, or cemented together into a pudding-stone. These appear to have been originally formed of concentric coats or layers of different colours, which vary in almost every specimen. The colours are for the most part yellow, brown, red, bluish-black, grey, and white: but these run into each other by an infinite number of shades. Others are spotted or clouded with different tints, and have much the appearance of Egyptian pebbles. They take an excellent polish, and are then often extremely beautiful.

These last appear rather more to resemble agates than chalk flints.* They are never found of a large size, seldom exceeding two inches in diameter, and generally are not more than one inch: they are of an oval or flattened form, which appears to have been their original figure, although they have evidently been subjected to a certain degree of attrition.

All the above mentioned pebbles are sometimes surrounded by crusts; and it does not appear clear whether these are not sometimes original, though perhaps stained by the ochreous substances in which they have been imbedded, or whether they are generally the effect of decomposition. Flint appears to be one of the most unchangeable substances with which we are acquainted. We see buildings constructed with flints that have resisted the agency of the atmosphere for many centuries without undergoing the smallest visible alteration, or having become whitened in the least degree. It is however well known to be liable to decomposition under certain circumstances; and it must be allowed that the combined action of moisture and various decomposing causes whilst a mineral remains buried in the soil, may produce effects which we can scarcely estimate.

Upon the whole, however, it appears to be extremely improbable, that any species of imaginable action could have converted a fragment of chalk flint into a substance so very different as one of the rounded concentric pebbles of the London gravel.

To assist us in endeavouring to obtain a just idea with respect to the origin of the different accumulations which are found in our gravel, it may be useful to consider the various changes which have taken place in our upper strata. Of these, although ignorant of their causes or their extent, we yet perceive the traces written in characters sufficiently legible.

Although the chalk has been originally formed at the bottom of the ocean, yet from some change which took place either in the level of the sea, or in the state of the strata, part of it probably at an early period has been above, and part below, the surface of the water, as at present; and this before the deposition of those strata which we now see immediately superimposed upon it.

From that date, and by the same cause as we see still producing this effect, did probably the formation of rounded flint pebbles begin. The chalk itself, being easily acted upon by the waves, became disintegrated, while the siliceous nodules were better able to resist this abrasion, though yet liable to be broken and rounded by friction against each other.

This effect takes place chiefly upon the margin of the sea. In deep water it may in some degree be produced by the action of the tides; but it is by the irresistible force of the billows and breakers that it proceeds with the utmost rapidity. Hence all geologists, in examining the history of the strata, have considered rounded pebbles as proofs of the existence of land elevated above the water.

At this remote period of the earth, when the outline of the coasts were, as now, deeply indented by gulphs and bays, but whose forms and situations had but little if any correspondence with the present, great changes must have taken place by the gradual action of the sea; and vast accumulations of pebbles of different materials, formed by attrition, would be thrown upon the shores.

In the ancient Parisian gulph this phenomenon is distinctly pointed out; nor are similar appearances wanting to demonstrate the action of the same causes in the Isle of Wight and London basins.

We have seen that in Alum bay there are layers of rounded pebbles in the vertical sand strata, which must have been formed prior to the subversion of the chalk, and before the deposition of the London clay. Similar rounded flints, and often of a whitened appearance, are found in the sand strata at the bottom of the blue clay in various parts of the London basin.

All these belong to the most ancient flint pebbles, formed by the same sea that deposited our blue clay and the calcaire grossier of France.

The thick bank of flint pebbles at Woolwich and Blackheath, separated from the chalk only by sand, appears like the section of an ancient beach, it being not far distant from the shores of the ancient marine gulph or bay which now forms the London basin. The fossil shells which we see in such numbers among these pebbles are almost all partly broken, and lie exactly in that confusion in which they appear when thrown up by the sea upon the shore. Water-worn pebbles are mentioned as occurring in the lower beds of the French calcaire grossier, and a number of other examples might be adduced; but these are sufficient to shew the contemporaneous agency of similar causes in different places. Prodigious banks of such pebbles are thrown up on our shores at the present time, and may serve very well to explain the origin of these ancient formations of flint gravel.

But with respect to the concentric pebbles above described, conceiving it to be improbable that they have been derived from chalk flints, I am compelled to look for their origin to some other source.

Considering them, as well as all the other bodies composing the alluvium, as detritus or ruin, a circumstance sufficiently shewn by the confused manner in which they lie, and by the water-worn appearance of a great part of them, it is unnecessary for us to confine ourselves to the chalk in seeking for the beds to which they originally belonged.

Siliceous nodules are frequent in other limestone strata; an excellent instance of which may be seen at Tillywhim quarry in the Isle of Purbeck. Trap also, as is well known, forms the matrix from which many agates are derived. Various silices, such as the carnelian, onyx and agate, invested with the usual crusts, are described by De Luc as being spread over the hills near a part of the course of the Rhine, while there are not in Europe any known natural strata that contain these stones.

One of the most remarkable circumstances in which the basin of the Isle of Wight differs from that of Paris, is the absence in the former of those siliceous formations so abundant in the latter.

The siliceous limestone, which contains also a burr-stone, covers half the bottom of the Paris basin. In the middle and upper beds of the calcaire grossier they have hornstone, and the nectic and lenticular quartz. The singular substance, called silex menilites, is well known to all mineralogists: it is found in the foliated argillaceous marls of the gypsums. In these marls they have also siliceous nodules, which are white, opake, flat, and mammillated, and also beds of flint. Silicified trunks of trees are also described. The meuliere without shells, above the upper marine formation, passes often into the state of flint, sometimes white and opake, and sometimes grey and translucent.

In their upper freshwater formation, a siliceous part containing the same shells as the calcareous is very abundant. The description of the several varieties of flints in these beds is as follows.

1. Flint, of a grey colour, translucent, fracture close and waxy, and even horny.

2. Flint, yellow, very translucent, very easy to break, fracture conchoidal and smooth.

3. A jasper flint of an opake whiteness like wax, fracture waxy and scaly, possessing little frangibility.

4. An opake jasper flint, a little cellular, and having all the characters of a compact burr-stone.

Such is the imperfection of language, that a correspondence merely in the general description of two mineral substances, is not sufficient to enable us to ascertain their identity. It must be allowed however, that most of the characters above enumerated will apply very accurately to many of the flints which I have described as composing the greatest part of some heaps of our gravel. I have also found among these many water-worn fragments of a siliceous stone that bears a considerable resemblance to the French meuliere or burr-stone.

If therefore we admit that the pebbles of our gravel are derived from the destruction of former strata, that many of them differ from any other siliceous bodies with which we are acquainted, and that these bear perhaps a stronger resemblance to the flints of the Paris beds than to those of the chalk (judging from some specimens of French flints in the Museum of the Geological Society), and if we have reason to believe that some of those beds formerly existed in this country, will it be considered as a conjecture rash and unwarranted, should I imagine that the substances in question have derived their origin from siliceous nodules, originally formed in strata which existed over our blue clay, but which have been disintegrated, and carried off, in one of those revolutions to which this part of the earth has been subjected ?*

The formation of the nodules of flint in chalk has frequently, and will probably much longer continue to excite the speculations of philosophers. But whatever was the mode in which they originated, we may fairly imagine that these siliceous masses in question now found in our gravel, (but which I have supposed to have belonged originally to regular strata) were formed in a similar manner.

The coats of the flints in chalk have been found by chemical analysis to consist of chalk mixed with the flint ; and it appears that all nodules formed in a matrix have crusts or coats, composed of a combination between the matter of the nodule and the enveloping substance.

The coats of these pebbles may be supposed therefore to exhibit a similar phenomenon ; and in them we may perhaps see a part of the stratum which they were at first imbedded in.

* The Egyptian pebbles are said to occur in a similar situation.

If it be asked what has become of the supposed matrix in which these flints were formed, and how could strata so considerable as they must have been, have disappeared without leaving a single trace of their existence ? It may be answered, that the difficulty is exactly the same in supposing them to be derived from the chalk; for no remains of this rock are to be found with these pebbles; and it is equally impossible to discover what has become of the chalk that must have belonged to the flint pebbles that are undoubtedly derived from it.

But when we see rolled pieces of granite, of quartz, and other primitive rocks, occurring frequently in the alluvium of this part of the country, though so far removed from the places where these substances are in situ, we feel so assured of the extensive nature and violent action of the cause that has occasioned such destruction, that we need not wonder if many strata have been reduced to a state of impalpable division, and have been scattered over the surface, so that not a fragment remains entire; or have been deposited in the depths of the ocean, where they may have formed new combinations that may at some distant period be exposed to view, and afford matter for the contemplation of future generations. The Hertfordshire pudding-stone has been already mentioned. It is composed of these concentric pebbles united by a granular quartz, and is most abundant in the neighbourhood of St. Alban's, but is found in many other places above the chalk. It occurs in large irregular masses in the gravel; but I am not aware that it exists any where in an extensive bed in situ.

To account for the appearance of this pudding-stone we have to suppose, 1st, the existence of a stratum superior to the chalk, containing under some form, the substance of which these pebbles are composed. 2d, the agency of some power capable of breaking up this stratum, of reducing it to fragments, and of disintegrating it, by removing the matrix containing the siliceous matter. And 3d. the deposition, either partial or general, of a solution of siliceous earth capable of cementing the whole together into one mass.

This formation is no doubt of ancient date, and long anterior to that of the present surface of the earth; a circumstance which is rendered probable by our finding masses of this pudding-stone itself water-worn, indicating, that since its cementation it has been subjected to some of these revolutionary processes, of which we have seen so many other proofs.

That all the ancient pebbles were not cemented together in a similar manner, is shewn by those in Alum bay, which are in loose sand; and by those which are found in the beds of sand in the blue clay, both in the neighbourhood of London and at Portsmouth.

But that some of the gravel may have been at a former period in the state of pudding-stone, and may have been disintegrated, is a circumstance also highly probable. Yet there does not appear any necessity for supposing that all our gravel has been originally pudding-stone, any more than that all sand has been sand-stone.

Another species of pebble which is very common, is a striped flint, or rather a kind of hornstone. These appear never to have had crusts, but owe their rounded forms entirely to the action of water. They may be supposed to have been derived from a bed of such a substance, which has been reduced to fragments. Beds of a striped chert very analogous to this I have seen in the island of Portland, alternating with the oolite.

Turf, so abundant in the north of France, is much less frequently seen in this part of England. The practice of draining, and the great attention paid to agriculture in our country, have much diminished the quantity of morasses and ancient depositions of this kind; and the great superiority of coal as a fuel, and which gives us a natural advantage over other nations, has rendered turf of little value.

In Lincolnshire however the quantity of marsh land is prodigious; and the well known and accurately described submarine forest, yet to be seen in that county, has already excited the attention of some of our naturalists.

The subject of the *Fossil organic remains*, found in the gravel, has been already so ably treated by a naturalist eminently qualified to do it justice, that I should have left the subject in better hands, did it not form so essential a part of an account of our upper strata, that to have omitted it entirely would have rendered some of the following observations less intelligible.

From the view which I have taken of the subject, it will be seen that I consider the fossil shells found in the gravel, as well as the gravel itself, as exhibiting proofs of the detritus or ruin of ancient strata. Hence specimens of all those fossils which belonged to the strata over the chalk may be expected to be found in it.

I am aware that the perfect state in which many of these fossil shells yet remain, has been considered as a proof that they have never suffered a removal, but that they have lived and died upon the spots where they now are.

That this is the case with some of the upper beds containing fossil shells, as the thin clay strata of Woolwich, Plumstead, &c. and perhaps of other places with which I am not acquainted, there can be no doubt. But the same argument will not apply to such as are surrounded by, and enveloped in, beds of water-worn pebbles and sand, which is evidently a confused mass, the consequence of ancient and violent changes, or the action of causes similar to what we perceive at the present day.

And if we reflect upon the manner in which the most delicate recent shells are buried when thrown upon the shore, in the sand and shingles of a beach, without being much mutilated, we shall not find it difficult to comprehend how very perfect specimens may sometimes be met with even in our gravel.

By attending to the revolutions that have happened to these upper strata, this subject will perhaps be less difficult to understand. Beds of gravel and sand containing fossil shells will be esteemed as the monuments of ancient changes though of different periods. But those shells grouped in families and contained in beds of foliated clay and marl, may be considered as still remaining in their original situations.

By this distinction we shall be able to separate real alluvial fossils, or such as have been washed out of regular strata from those that have never been disturbed; and the various states of violent convulsion, as well as of quiescence, which the ocean must have experienced during the several eras, the geological history of which we have been considering, are sufficient to account for these appearances.

In a work lately published by an eminent fossilist, I have met with an opinion, that all the spoils of terrestrial and submarine productions which we find buried in the strata in this country over the chalk, have been transported from distant climates, and have been deposited in a tumultuous manner by some great convulsion that blended them in one common grave. I should not have thought it necessary to allude to this idea, if I had not understood that it has been considered by some as demonstrating that all the strata over our chalk are alluvial.

The grounds upon which this supposition is made, is the observation that the recent analogues of most of these fossils are now inhabitants of the torrid zone. The extreme delicacy however of most of these shells, as well as their perfect preservation (as Mr. Parkinson has already observed,) precludes entirely the possibility of their having been brought from distant places, and they serve merely to shew that this part of the globe must be very different, relatively to such species of animals, from what it was at the period of their entombment.

In some beds of pebbles and gravel fossil shells are very numerous, as in those of Woolwich, Harwich, &c. and with these alternate frequently beds of clay and sand, containing shells regularly distributed, entire, and apparently undisturbed. Of these shells Mr. Parkinson observes, some belong to species now only found in distant seas, and others appear " not to differ specifically, as far as their altered state " will allow of determining, from the recent shells of the neigh- " bouring sea."

But granting, as we must, that the formation of pebbles has taken place at different periods, it must be extremely difficult, and perhaps impossible in all cases, to distinguish whether they are now to be seen in the places where they were at first deposited, or whether they may not have repeatedly been moved.

In many beds of gravel delicate shells are so abundant that the cause which placed them there could not have been very violent; whilst others are found totally destitute of organic remains, except such as are impressed upon the substance of the pebbles themselves. Among the latter may be enumerated, pectines, anomiæ, the interior casts of echini, and impressions of the spines and plates; zoophytes of unknown genera, some resembling alcyonia, are also frequent. It does not appear certain whether all these may not have belonged to the chalk strata, but Mr. Parkinson is of opinion that some differences are observable between these echini and those of the chalk. M. Desmarets has described in the lower gypsums of Montmartre fossils similar to those of Grignion, many of which are echini of the genus spatangus, but different from the spatangus cor anguinum found in the chalk. At Grignion too, there are echini which belong to the genus clypeastra.

Impressions of organic remains very rarely occur in the concentric pebbles, particularly those of the Hertfordshire pudding-stone; * but the yellow calcedonic flints frequently contain alcyonia.

The *Fossil-bones* of quadrupeds are frequently found in the alluvium of this part of England, and they appear to be of several dates.

The most ancient are entirely petrified, and where found in the gravel, appear to have been washed out of the strata in which they were originally imbedded, which, from the part of the matrix still adhering to them, appears to have been calcareous. Mr. Parkinson has described some of those found at Walton and Harwich, which however were too much broken to enable him to ascertain distinctly the animal to which they belonged, but he conjectures them to be parts of the Mastodon of Cuvier.

The next class contains the bones of the elephant, rhinoceros, hippopotamus, and the Irish elk, which are no longer natives of this climate. These however are not petrified, and though generally in a state of decay yet are sometimes quite perfect. They are particularly abundant in Suffolk and Norfolk; but have also been found at Brentford, in the Isle of Sheppey, and several other places. And it is particularly important to remark that these are never found *in* the

* A very fine example of one occurs in a specimen in the museum of the Geological Society, presented by Leonard Horner, Esq. It is a small bivalve resembling a pecten.

stratum of London clay, but always *upon* it, and frequently accompanied by marl and freshwater shells.

Other bones of ruminating animals, as those of the horse, ox, and stag, not different from the living species, are frequently dug up at small depths, and are covered by peat, gravel, loam, &c.

In the freshwater formations of the basin of Paris the bones of terrestrial animals are found, which do not belong even to known genera, and many of those found near the surface in their alluvium, belonged also to animals of great size, and which are now found only in countries very remote.

We see therefore that a similar succession of animals has lived in this portion of the earth, during the various stages of its habitable state.

V. *Concluding Observations.*

One of the most interesting consequences deducible from the above examination of the last formed strata of this country, is, perhaps, the view which it seems to afford us, of establishing, in some degree, a series of epochs between the deposition of the chalk strata and the formation of the present surface of the land; not indeed to be distinguished by computable time, since no date can be affixed to any of the changes to which I have alluded, but an order of succession of the great events at least appears more than hypothetical, which it may be useful still further to consider.

The origin of the calcareous matter of which the chalk formation is composed remains one of those hidden mysteries on which all the speculations of geologists have not thrown any certain light.

In the several strata of chalk however, although their sources were probably not very different, we may perceive several circumstances which indicate the action of modifying causes in each deposition, that seem to have had considerable influence upon organic life. The almost entire absence in the lower beds of those siliceous nodules that are so numerous in the upper one, and the remarkable differences in their animal remains, furnish sufficient reasons for this supposition.

Calcareous, argillaceous and siliceous matter, the whole or a part of which was in a state of solution, originally formed the mass of this formation. Of these the argillaceous seems to have subsided first, but more or less mixed with calcareous earth. The silex now occupies the upper division, but whether separated by the action of chemical affinities, or introduced subsequently, does not yet appear. The tranquil state of the ocean during this period may be inferred from the perfect preservation of the numerous delicate fossil organic bodies now found in the chalk.

An era of turbulence seems to have succeeded; during which however the depositions of the plastic clay and sand denote certain intervals of repose. The surface of the chalk already solidified was in a certain degree, though irregularly, subjected to the agency of water in motion; and other causes might have combined in destroying the original horizontality of its position. But where the vast bed of London clay subsided, the sea must have regained its former tranquility.

The numerous vestiges of vegetables as well as of animals to be found in this stratum, whose recent analogues are now seen only in tropical countries, involuntarily leads the mind to contemplate with wonder the altered condition of this portion of the globe. Have the laws which regulate the place and motions of this earth in the system of the universe been subjected to change? Are there in these any sources of irregularity or gradual alteration, the proofs of which can be detected? these are questions for astronomers.

If we consider that the flinty chalk is somewhat above the level of the sea at Woolwich and Gravesend; that it dips under the Isle of Sheppey and disappears; that at Margate it has been so elevated that a considerable part of the lower chalk is now seen, the whole of the upper or flinty chalk being gone; that at Dover it rises to a vast height; that on the north side of the Thames it appears at Purfleet opposite to Gravesend, but immediately disappears to rise no more on the coasts of Essex and Suffolk.—If we reflect on the rapid dip of the chalk at the Hog's back, between Guildford and Farnham, with the many hills and hummocks of chalk to be seen in the counties of Suffolk, Norfolk, &c. we may perceive evident proofs of the great irregularity of the ancient surface of this stratum, and a part of the elements which may enable us to trace the limits of the land and sea at that period.

In speaking of the formation of the gravel, the probable mode has been detailed, by which the mountains of chalk originally appearing above the sea may have been worn away, cliffs have been formed, and the flints broken and rounded into pebbles. Of the early existence of this process, we have seen proofs in the vertical bed of pebbles of Alum bay, and in those frequently found in the sand of the plastic and blue clay in many other places. And also in the lower beds of the calcaire grossier of the basin of Paris.

We have seen also that the extraordinary event of the elevation or subsidence of the chalk of the Isle of Wight and Dorsetshire must have taken place after the deposition of the great stratum of blue clay.

A change of this kind, of which we have no parallel in human record, it would be in vain to endeavour to account for; but it must have been an event of itself sufficient to produce great changes in this part of the globe, and must have been accompanied by the most extraordinary phenomena. From the correspondence in the situation of the chalk and the accompanying strata in the Isle of Wight and Dorsetshire, it should seem, that the range of chalk hills in each of these places was at first united; and thus a marine gulph was formed, open to the east, in which a part of the depositions at that time going on in the ocean subsided.

The observations of several geologists have shewn the natural tendency which the sea has to fill up æstuaries, and to throw up bars across their mouths by the accumulation of pebbles and sand. Many remarkable instances of this process have been observed on the shores of the Baltic, and even in this country. It appears also that such gulphs and bays are frequently converted into freshwater lakes, of which Loo Poole in Cornwall is an excellent example.

As it is most philosophical to seek for the solution of natural phenomena from known causes, might we not suppose that a similar circumstance has converted the gulph we have contemplated (now partly occupied by the Solent) into a lake of fresh water? If the size of the bar necessary for this purpose should appear extraordinary, we have only to recollect the Chesil bank, which now joins the Isle of Portland to the main land; and many others of the same description.

With this subject in my mind, while examining the cliff at Brighton, which has been already described, I could not resist the idea that it might possibly be the remains of this ancient inclosure of the lake. That it exhibits the vestiges of a vast and ancient accumulation well fitted for this purpose, there can be little doubt; and it is evident, that it has extended in the necessary direction, it being now a vertical section of what must have run out far into the sea.

Whether such a supposition as this can afford a solution of the phenomenon of strata formed in freshwater appearing over marine strata, I shall leave to be determined by those who are competent to such a task.

Of the unfathomable antiquity of these great and numerous collections of freshwater in the ancient world we have however abundant proofs, in the admirable researches of Cuvier on the extinct genera of animals which inhabited their borders.

It would perhaps be impossible for us now clearly to ascertain what could have furnished the prodigious quantity of calcareous, and still more the siliceous matter which they held completely in solution; in modern lakes we have examples of strata now forming of marle arising from the shells of the numerous freshwater animals which inhabit these shells, but these beds (as far as is yet known) are not consolidated.

Was a portion of the calcareous part of these ancient strata derived from the surrounding calcareous hills, which might have been lofty? If we examine the section of the Isle of Wight, the probability appears considerable, that the strata of chalk must have stood at a considerable height above the lake; although it has subsequently undergone the same levelling process, to which all the surface of the island has been subjected.

As connected with this subject, I shall quote a passage from Bergman's Physical Geography published in Swedish in 1769.

" At Langesaltza in Thuringia, they find under the vegetable
" earth a calcareous and porous tufa; in other parts a fine white
" sand mixed with river shells; below, a bed of hard stone, under
" which is a bank of porous stone or sand. Lower still they find
" a bed of hard stone, then tender stone and sand; afterwards peat
" formed of a mixture of leaves, barks of wood, roots, river shells,
" &c. Lower, yellow sand; and finally, grey fullers' earth mixed

" with marine bodies. The thickness of the beds of stone varies " from 6 to 12 feet. They contain river shells, bones, sculls of ani- " mals, kernels of fruits, ears of corn, &c. These strata extend " quite under the city to the borders of the Unstrutt, near to which " are seen strata of alabaster and limestone, the detritus of which " has probably given origin to these beds. It is to be remarked " that no remains of marine animals are found above the clay where " the ancient beds commence."

A very interesting account has been given by Von Buch of a freshwater formation in Locle in the district of Jura. It is contained in a high inclosed valley surrounded by mountains of white compact limestone; and consists of various alternating beds of marly limestone whitish and somewhat friable, bituminous shale, coal, hornstone of a smoke grey colour, and of a fine splintery or imperfectly conchoidal fracture, and containing crystals of quartz; also of opal of a brownish black colour, glistening lustre, and perfect conchoidal fracture. Both the limestone and hornstone contain freshwater shells, among which may be distinguished the helix cornea and bivalves.

From these and other accounts it appears probable that these freshwater formations were purely local, and there appears no necessity for supposing that the others were any thing more than local deposits in a former state of the earth.

I am aware that such formations have lately been traced on the shores of the Baltic, in the south of France, Spain, Germany, and Silesia; but this can only prove that fresh water lakes were in former times as at present very numerous and often extensive.

One of the most striking differences between these ancient lakes and modern ones, as has been remarked by Messrs. Cuvier and Brongniart, is the property possessed by the former of forming siliceous strata.

It would seem to have been a circumstance accompanying the last great revolution which the earth has undergone, that siliceous earth has been held less abundantly in solution since that period. That event appears to have been accompanied by a process of destruction merely; but former changes were alternately destructive and renovating or conservative. The animal and vegetable remains of the ancient world are frequently impregnated with siliceous matter. But I believe no well authenticated instances can be adduced of such a process going on in our times. Petrifaction, indeed, in the proper sense of the word, seems now to have entirely ceased.

In the strata over the chalk in France silicified organic bodies are abundant: in our upper strata they are rare, if we except those found in the gravel whose original situation is yet questionable. Indeed the only instance with which I am acquainted in this country in the strata over the chalk, are the siliceous fossils of Feversham already mentioned: some of these are entirely calcedonic.

The existence of the marine strata placed above the lower fresh-water formation in this country, as well as in France, is a circumstance much more difficult to explain, and would seem to require either a rising of the sea or a sinking of the land in this part of the globe.

Alterations in the shape of the coasts, and the accumulation of sand and pebbles in various parts of the sea, affect the tides so considerably, as to occasion them to rise to very different heights at the same places at different periods; yet no change of this kind can be imagined sufficiently great to account for an effect so considerable as has been produced.

Instances of marine strata placed over those formed in fresh water have been observed not only here and in the basin of Paris, but in other places. One is mentioned by Professor Herman, of Strasburgh.

The strata are situated in the department of the lower Rhine, in the mountains of St. Sebastian, one of the lowest in the chain of the Vosges.

The great quantities of white calcareous marl with freshwater shells, so frequently found on the top of the London clay, and enveloping the bones of land animals, would seem to denote a marshy country, and one containing a great deal of stagnant water. This seems to have been the first state of the country at the time of the emerging of the land after the deposition of the blue clay.

In this marl and over the clay is the first appearance of land quadrupeds, agreeing in this respect with the same observation made by Cuvier on the calcaire grossier, above which in France their remains are found in abundance.

The changes preceding or accompanying the upper marine formation perhaps destroyed part of the superior strata, and deposited many of those extensive beds of shells now to be found over the London clay. But the nature of the last original marine strata of this country, the revolutions they may have undergone even in the ancient state of the earth, are circumstances which can probably no longer be explained.

Whether the existence of the second freshwater formation in the Isle of Wight will admit of the same solution as has been proposed for the first, must be left, like it, undecided: but it appears to have taken place in a lake possessing the utmost tranquility.

Upon the whole it must be allowed that the points of resemblance which have been enumerated between the superior strata of this part of our island and the adjoining part of the continent, are too numerous and striking to be the result of accidental causes, and demonstrate in the clearest manner that they were occasionally subjected to the same general laws. Whilst at the same time the variations are so considerable, that the effects of these causes appear to have been much modified by local circumstances.

But I shall now venture with less hesitation to draw an important conclusion from the section of the Isle of Wight, which has been already described, and which of itself forms a volume in which we may read the geological history of several of the latest revolutions which our earth has experienced.

The idea I allude to is, that the last freshwater formation, as well as all the other strata which we have been considering, is *anterior* to the great event which gave the last shape and surface to our land.

In the highly inclined and vertical positions of the strata of Alum bay, we see the effects of some great convulsion of nature, previous to the formation of the last strata.

In the horizontal deposits of the North side, we see strata of great extent and antiquity yet formed at a later period. But in the outline exhibited by the surface of the island, and which has no reference whatever to that of the strata, is plainly to be perceived the effect of a general and powerful agent, which has subsequently formed the whole of the contour by one bold and sweeping outline.

It may be interesting to see how the same result can be obtained by a careful survey of different portions of the globe.

Messrs. Cuvier and Brongniart have laid considerable stress on the observation, that the outline of the present surface has no resemblance whatever to the undulations of the strata derived from the irregularity of the bottom of the basin. But how much more striking is this in the Isle of Wight? By no ingenuity of reasoning can the present form of its surface be derived from the bottom of that ocean which deposited the chalk; nor would it be produced by any of the causes now acting; and nothing remains for us but to admit that it has been the effect of an extraordinary and an extensively acting cause.

In the smooth and undulating surface of the chalk hills, in the banks of gravel of great extent, in the deep hollows often filled up again by the detritus of regular strata, in the direction of the principal ridges and valleys, we cannot but recognize the effect of *water*, the only agent which we know to be capable of producing such appearances.

But under what influence has this power, fully equal to such a purpose, been directed? What could give sufficient energy to a body at other times so tranquil? These are questions of which the complete solution will perhaps ever remain in obscurity.

Yet already we have had sufficient proofs that the sea has not always maintained the same relative level; that it has alternately risen and fallen; although to ascertain the distance of time between these changes be absolutely beyond the reach of human sagacity.

Let us then imagine an ocean in a violent state of agitation. The hills of chalk, and the last depositions of the globe are torn to pieces; the flints are dispersed and rounded by attrition against each other; finally, currents carry them to great distances, and lodge them in hollows worn by the waters, or form them into ridges and other accumulations. Fragments of other rocks are intermixed; forests are torn up and levelled, and, with the vegetable soil, formed into morasses. The inhabitants of the land are destroyed and buried deep in this dreadful ruin. But a more surprizing revolution ensues. Disorder ends; the waters retire; the northern continents are disclosed, become fitted for vegetation, and are peopled by the tribes of animals which now inhabit them.

VIII. *Remarks on the Vitrified Forts of Scotland.*

By J. Mac Culloch, M.D. F.L.S. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich. V. Pr. Geol. Soc.

THE contest about the vitrified forts of Scotland having for some time ceased from an apparent want of new matter, it may be deemed superfluous to revive it by the description of any more of these extraordinary structures. But some appearances which seemed to have been overlooked having occurred to me in examining these works, I thought it might yet be interesting to those who took a part in the former discussion, to receive any additional remarks which might assist in clearing up the points in dispute.

As far as archæology is concerned in the question, I deem it useless to enquire to what æra they are to be referred. That they belong to a people who had not learned the Roman arts is probable, since they contain no calcareous cement. But that this is a certain conclusion I am not inclined to admit, as the knowledge of a simple fact among a savage people does not necessarily imply the power to direct it to use. The ability to detect calcareous stones, the means of quarrying them in certain situations, and the power of transporting them from great distances to places where they do not naturally exist, must have been possessed by these people before they could have directed to any useful purpose this naked truth derived from their conquerors. To instance only those vitrified forts which are found in Galloway. There is no limestone to be procured in that country but by a very distant land carriage, or a very circuitous route by sea. It is evident that a commercial system of some sort must have been established before the inhabitants of these countries could have cemented their buildings with lime, however they might have been acquainted with its properties. It is equally a matter beyond the power of modern investigation to discover whether they were the works of the aboriginal Caledonians or of their Danish invaders. Neither analogy nor examination of the remains throws the least light on the subject, a subject which as it is beyond the reach of historical or traditional evidence, seems equally divested of all those circumstances from which truth is sometimes elicited. It is nevertheless a general opinion that they are remains of the earliest works of ancient inhabitants. This too is a proposition which appears to rest on a very vague sort of reasoning. The same Antiquaries suppose that the well known circular Pictish towers were built before the use of iron, but admit that they are of more modern date than the vitrified forts, from the greater artifice apparent in them. It will however be clear to any one who shall examine the vitrified fort near Amwoth in Galloway, that the ditch which has been excavated for the purpose of giving the fort a scarp all round, has been cut down by iron, or at least by a tool of metal. It is from the greater accumulation of soil on the ruins of the vitrified walls, an accumulation often sufficient to conceal them entirely from the view, that we are (if from any thing) entitled to consider them as erections of a date more ancient than the towers of Glen Elg or Dun Dornadilla, or than any of the works as yet examined in which unvitrified masonry has been used. But it is superfluous to pursue these archæological difficulties further.

The question on which the two contending parties have been most at issue, was, whether the vitrification was the result of design or accident. While one party asserted that a regular process had been carried on for the purpose of making a solid wall, the other supposed that these walls might have been originally constructed of stone and wood united, and that accidental fire, or the attack of an enemy, had destroyed the compound structure, producing in consequence the vitrification now to be traced in them. Mr. Williams and Mr. Fraser Tytler are the most conspicuous leaders on each side.

It seemed to me that light might be thrown on the question, by examining with mineralogical accuracy the substances of which these structures were composed, and noting the changes which each had undergone from the operation of the fire, and also by observing whence the stones had been derived which were used in them; and that the question of accident or design might be illustrated by examining in the laboratory the degree of heat necessary to produce the requisite appearances in the stones which actually exist in these structures.

In the present more diffused state of mineralogical and geological knowledge, it is unnecessary to refute the notion of their volcanic origin in a paper addressed to a Society like this. For the purpose of the ordinary spectator, that refutation may be trusted to the increasing progress of natural knowledge.

The hill of Dun Mac Sniochain, which lies in the plain, now supposed by some to be the site of the ancient Beregonium, has been long noticed as the seat of one of these extinguished volcanoes. Having seen specimens of pumice and lava (as they were called) collected from it, I was glad to have an opportunity of investigating a very accessible specimen of what I concluded to be a vitrified fort. Such it proved.

The drawing, pl. 2. fig. 1, which accompanies this paper, contains a ground plan of the work, as well as I could determine it by pacing, and without tools to clear away the sod. Those who have seen similar works know how completely they are sometimes covered with the soil; a circumstance which, as I have just noticed, perhaps more decidedly than any other, marks their high antiquity. Imperfect however as their traces generally are, the drawing will serve to show a very peculiar form in that which is the subject of the present paper, and a plan differing much from the uniformity of structure and rudeness of design which have been supposed to distinguish these works.

The long narrow hill on which it stands is nearly precipitous along three quarters of its circumference; at the other end it rises from the plain with a very accessible acclivity. By inspecting the plan, it will be seen that a series of parallelogramic works have been constructed so as nearly to cover the principal and precipitous part of it to the very edge. The greater portion of the hill being thus occupied by two of these works, the strongest part was cut off by a wall from the more accessible end, thus forming a sort of citadel or place of retreat at the last extremity, a practice very common in the ancient peninsular fortifications of Cornwall, in Castle Trereen for example, and in a similar castle at Zenor. To occupy and defend the vulnerable side of this position, the outer work appears to have been placed without the principal area, that from it the enemy might be seen and opposed in every part of his ascent. This disposition bears incontrovertible marks of military design and experience. Were a modern engineer to defend Dun Mac Sniochain, he could do little more than build a fort to occupy the ground and contain his men, erecting an out-work to command the approach.

I have thus particularly detailed the military relations of this work, to show that these forts very probably belong to an age of some talent and improvement, a notion adverse to the suppositions of those who have conceived them to be the efforts of the rudest barbarians. But the ignorance and rudeness attributed to nations of mere warriors and hunters is falsely assigned.

The history of infant society shows on the contrary instances of acute reasoning, of ready invention, of perseverance and prowess, which would be in vain sought among the enlightened populace of modern times, nay even among those who are far removed above that rank. But this ability and vigour of mind have been necessarily directed to those objects only, which were useful or honourable, or were then in fashion. The abilities of infant nations require to be compared with their necessities, and to be measured by their best works, not by their worst.

The whole length of ground enclosed beyond the cross wall is about 200 yards, and its breadth is about 60. Within this space are two works, the one containing a perimeter of 153 yards, and the other one of 110. These, according to the modern military computation for the defence of a redoubt, are capable of holding more than 500 men. The perimeter of the external work is 96 yards, a space nearly capable of disposing of a hundred more. We are unable, from ignorance of their weapons and modes of warfare, to determine in what way these works were occupied or defended, but on any supposition it appears that this must have been a military fort of some magnitude and consequence.

I have entered into the details of the magnitude, and figure, and military importance of this work, for the purpose of setting aside another hypothesis with regard to the vitrified forts. They have been supposed by some to be merely beacons, and that the vitrification has been the result of the combustion of those heaps of wood which were used for signals. The supporters of this opinion have asserted that they always occupy the highest elevation, and that many of them are so placed as to be visible from each other. This is not true. The fort at Amworth is not on the highest ground it might have occupied, nor is the fort of Dun Mac Sniochain so situated: but they are both on the strongest ground. Where the strongest and highest ground coincide, a case very common in hilly countries, (I speak of military strength of ground as connected with ancient modes of warfare) there, as at Craig Phadric, they naturally occupy the summit. I may add, that no fort has hitherto been discovered between this and Craig Phadric, except that at Dun Dheairduihl, nor have any been observed in its neighbourhood in other directions. I might strengthen this argument by referring to the descriptions of other similar works, but I prefer arguing from those which I have seen.

It now remains to enquire, if by any examination of the walls of Dun Mac Sniochain, light can be thrown on the causes of its vitrified appearance, and whether it was the result of design or of accident.

The remains of walls in the other vitrified forts, noticed by different observers, have been so well described, as far as relates to their general appearance, that little can be added on this head. It may be sufficient to say, that they appear in the present work to be about twelve feet in thickness, and are now nearly buried under the soil.

One circumstance however requires attention, as some false speculations have been founded on it. Both the outside and inside of the walls near the ground are rendered much thicker than their true measurement shows, by a heap of loose stones accumulated against them, and this renders it difficult in the present state of things to ascertain their real dimensions. It has been supposed that this was done with a view to strengthen the work, or else that it was an effect of the rude manner in which they were supposed to be erected. It would have been an extraordinary system of defence which should have heaped up a pile of loose stones on the outside of a wall. Modern warfare is satisfied when its ordnance has produced such an addition to the face of an enemy's bastion. A little attention also to the angle which loose stones assume when they are at liberty, might have shown that such a system would not only have prevented the defenders from approaching their own walls, but would in fact in small works, such as those of this fort, have occupied a very considerable portion of the included area.

It is the dilapidation of the unconsolidated parts of the building which has produced this appearance. The thickness of the walls of this fort, as nearly as it can be appretiated, is, as I have already stated, twelve feet. They bear the marks of vitrification throughout their whole extent, but in some places it is more complete than in others. In no case does it seem to have extended more than a foot or two from the foundation, and the most perfect slags are found at the bottom of the wall. As we proceed upwards, we find a mixture of porous slag with stones which having been but partially fused have adhered together in a mass. Higher still we meet with stones which though unvitrified are roasted by the action of the heat, and at length the marks of fire diminish until they almost entirely disappear, leaving only a heap of loose and unconnected stones. The loose part of the wall having fallen through time, has caused that accumulation of rubbish which we find about the vitrified parts. On account of this mixed construction, we have no means of ascertaining the original height of these works; but if a judgment may be formed from the quantity of loose stones which are found at the base of the walls, it was probably not considerable. Nor indeed would a work which was intended for defence from within admit of a greater height of wall than five feet, or that over which a man might look, a height which is equal to that of the ancient British field works, if this may be determined from some of the perfect fragments which remain in Cornwall.

Of one of the most remarkable of these, I have given an account to the Antiquarian Society. It is the fort known by the name of Castle an Dinas, in the parish of Ludgvan, in that county. Here the altitude of the work is determined by the perfect finish of part of the remaining wall, which consists of well-fitted dry masonry, the strength and solidity of which show that it was not a temporary enclosure, but a sort of citadel, or work of permanent defence. The wall is here only five feet high, and from this I am inclined to conjecture that the vitrified forts did not exceed this height. Nor indeed are the accumulated ruins about them sufficient to give reason for suspecting that they ever were of a greater elevation. It is deserving of remark, that the vitrification of the outer work is not so complete as that of the inner ones.

Before examining the materials of which the wall is composed, it is necessary to mention the mineralogical nature of the rock on which it stands, and that of the immediate vicinity. The hill of Dun Mac Sniochain is formed of limestone, lying in schistus, similar to that which constitutes the neighbouring island of Lismore. The schistus and the limestone alternate, but the latter is the predominant rock. The hill itself is perfectly insulated in a great alluvial plain. To the west this plain is bounded by the mountains of Benediraloch, which descend abruptly into it, approaching at their nearest point within half a mile or less of the fort. These mountains are formed of the old rocks common to this country, granite, gneiss, mica-slate, quartz rock, and porphyry. A long mountain of trap rising at the borders of Loch Etive, skirts the edges of these hills for a considerable space, terminating on the plain of Connel by a trap breccia, that pudding-stone well known to tourists as occurring in various places from Connel to Oban. This breccia, where nearest the fort, is at least half a mile distant from it. As the geological site of the rock does not concern the present inquiry, I will limit myself to its mineralogical description.

It consists of rounded pebbles of different magnitudes, cemented by a paste of a mixed white and brown colour. The pebbles are generally small, and are much more numerous under the size of an orange than above it. There are very few of considerable magnitude. They exhibit for the most part different varieties of trap, or greenstone, all of which have been rounded previously to their entanglement. Of these there are purple, red, gray, and dark blue specimens, varying as much in solidity of texture as they do in colour, and more or less homogeneous in their appearance. Many of them are of an amygdaloidal structure, containing imbedded grains of calcareous spar, zeolites, and green earth, and some are perfectly cavernous and scoriform. Besides these pebbles of trap, there are rounded pieces of quartz of different colours, white, gray, and red, cemented in the common ground. In the specimens which I examined I could not trace any other kind of rock. The paste by which the whole is cemented is of a peculiar quality. It is either dark purple, or brown, or mottled, or gray, or a dirty mixture of brown, white, and dull green. It may be scratched with the knife, has an earthy smell when breathed on, and effervesces with nitrous acid. Its fracture is not properly granular, but rather of the small splintery. Before the blow-pipe it is fused into a dark glass.

On a minute examination it appears to consist chiefly of fragments of trap cemented by a whitish substance, which proves to be the hard variety of calcareous spar, mixed with a sand of trap. This trap sand is generally of a dark purple colour, resembling many of the imbedded pebbles. Although this sand is the predominant ingredient in the paste, there are also found in it grains of quartz, minute zeolites, garnets, crystals of calcareous spar, and here and there prehnite, diallage, and chlorite slate, as far as it is possible to speak decidedly of objects so very minute. The spar which cements this sand into a common paste surrounds every grain so as to form them into a perfect breccia, and enable the whole to break with the splintery fracture above noticed, instead of a granular one. Here and there the paste occupies large interstices which have been formed by the approximation of two convex surfaces of considerable extent, and from these it may be traced insinuating itself through all the grains of the mass. It is evident that the calcareous spar has been introduced while in a state of fluidity among the sand and gravel, as the larger pieces of paste may be observed to envelope the grains of trap. Generally therefore we may consider the pudding-stone of Lorn as a congeries of trap sand and trap pebbles, cemented by calcareous spar, a rock often designated by the improper name of trap tufo. This however is not the place to enquire into the means by which the mass was consolidated. That it is a case of an agglutinated rock differing greatly from the ordinary sandstone breccia, or the ferruginous and argillaceous pudding-stone, is very apparent. It resembles them indeed only superficially and in its mechanical texture, and it will be worthy the labour of geologists to direct their attention to the pudding-stones of this coast with more care than they have hitherto done. The other rocks are too well known to need any description.

The walls of the fort are found on examination to consist partly of the old rocks before enumerated, and partly of that which I have now mentioned. Gneiss, quartz, granite, mica-slate, clay-slate, pudding-stone and pyritical slate are seen entangled together, with a very small proportion of the particular rock on which the fort itself is founded. The source whence these rocks were derived is evident, with the exception of the pyritical slate, which I could not trace in the neighbourhood.

I have now to enquire what motive could induce the builders of this work to reject the stone which lay at their feet, and to fetch from such a distance the large quantities required to raise their walls. It is particularly remarkable, that although the plain and shore are covered with fragments, yet these are almost entirely fragments of the primary rocks. I state this for the purpose of obviating a supposition that may be adduced to nullify the argument which I am about to derive of a previous intention in the builders to vitrify their work, from their having neglected to use that rock on which the building was erected, and which was not adapted for the purposes of vitrification. It might otherwise be suggested that they collected the loose rolled stones of the plain, as being ready broken to their hands. But besides that the pudding-stone is rare among these fragments, the pieces of the wall which have not felt the fire are angular and not rolled stones, showing pretty clearly that they were not collected on an alluvial plain, but broken from the rocks where they were formed.

Now, in the walls, the pudding-stone which we shall presently find to be the only vitrifiable ingredient, predominates to such a degree as to occupy the greater part of it. Hence it appears at least a probable conclusion, that the builders were acquainted with the effect of fire in destroying limestone, and that intending to erect a vitrified wall, they rejected that which was unfit for their purposes, however conveniently placed. Had the object been to erect a dry wall of stone and wood the limestone would have equally answered their intentions. This notion of a design to vitrify seems to receive additional strength from the apparent solicitude and labour employed in introducing so much pudding-stone into the work. It is very likely that accident had taught them the vitrifiable nature of this ingredient; a piece of knowledge the more probable, if, as there seems little reason to doubt, they were acquainted with the art of making iron, an art which we need not deny to them when it is known to many of the inhabitants of Africa who are in a very low state of civilization.

Such are the consequences I would try to deduce from the mineralogical considerations belonging to this question.

It is now proper to examine the changes which the several substances have undergone, that we may, if possible, form some rational conjecture on the degree of heat to which they have been subjected, and on the probable means by which that heat was produced.

Where the quartz has been most exposed to the fire it has become brittle and easily pulverizable. The granite too is brittle and crumbles to pieces. The gneiss and mica-slate are also rotten where they have contained much iron, in consequence of the oxidation of that metal. Where purer they have remained unchanged, as we might expect from the well known properties of some of the varieties of mica-slate. Often where their flat surfaces have been in contact they are agglutinated from the superficial vitrification of the quartz which they contain when united to the potash produced by the fuel. This is also the cause of the glazed surface which covers the clay-slate and which has frequently occasioned numerous small pieces to adhere in one lump. In many places the mica-slate has been so softened by the application of heat as to have bent and conformed itself to the neighbouring protuberances, undergoing at the same time no great change of texture, unless when much impregnated with iron; an appearance perhaps assisting to confirm that explanation of the contortions of the gneiss beds which attributes this effect to the action of heat.

Very little change appears in the specimens of common slate which I have taken from it. If any limestone has found its way into the wall, it has probably been calcined, and subsequently assisted to bring into fusion the refractory earths. It is to the pudding-stone however, that the main part of the vitrification is to be attributed. Without this it would have been only a mass of burnt rocks, and specimens of it may be taken from the wall in every state, from that of a black glass, to a spongy scoria capable of floating in water. There are also many pieces, which having been exposed to a lower heat, exhibit a gradual succession of changes, from incipient calcination to complete fusion. This therefore is the cement of the building; and it has been so mixed through the whole, that there is scarcely a part (I speak of the foundation) which has not been united into a continuous mass by the fusion of this substance. The last stone of which the changes are worth noticing, is the pyritical slate. In general it has become disintegrated in consequence of the sublimation of the sulphur contained in the pyrites. But many specimens may be taken from the wall, where the pyrites has felt no change, proving evidently that it has scarcely undergone the action of heat. In the vitrification therefore of the pudding-stone, and the integrity of the pyrites, we are furnished with the two extreme points of temperature under which this work has been raised. How these are to be reconciled is a new difficulty. It is unnecessary to examine the highest temperature at which pyrites can maintain its integrity, as it is known to be low. It is equally useless to examine into the powers of the granite and quartzy rocks to resist heat, as they also are well known.

The fusibility of the pudding-stone arises partly from the fusible nature of the substance which I have described as forming its proper paste, but in some measure also from that of the amygdaloids and greenstones imbedded in it. It is in consequence of the carbonic acid contained in the calcareous crystals which these amygdaloid pebbles exhibit, that the inflated scoria are produced; for it may be easily traced to them through a regular gradation. To pursue this subject experimentally, I thought it necessary to submit various parts of this rock to the furnace, that I might ascertain the degree of heat necessary to effect the corresponding changes in it, and the fragments were accompanied by one of Mr. Wedgwood's pyrometer pieces.

The spongy scoria remained unchanged, and the natural amygdaloid was sometimes unaltered, and sometimes disintegrated by the calcination of its lime, without undergoing any mark of fusion in a heat of 20°; a heat at which brass is melted. From 20° to 30° the amygdaloid underwent no change except a slight vitrification on the surface; at 40° it was much affected, and was fused into a glass at 60°.

Having excited the fire to 100° I exposed to it various parts of the pudding-stone, which had not been affected in the heat at which the amygdaloid was changed. Some of these were vitrified, and became precisely similar to many of the specimens taken from the wall, whilst others continued to resist, for a long time, even this intense heat; a heat at which many varieties of earthenware are baked. It is unnessary to relate all the experiments which I performed on the different substances, as it is not my object to state these matters for the purposes of chemistry. Those which have been adduced are sufficient to prove that some of the fused substances must have been brought to that condition in a heat not less than 60 degrees or upwards of Wedgwood's scale. Such then, at least, is one temperature at which the walls of this fort have been fused. It may have been much greater. It is perfectly evident that if a temperature of 60° existed in one part of the wall, pyrites lying near it must have been decomposed. There could be no such discordancy of temperature existing simultaneously, and so near, in a mass of this construction. Hence then it follows, that the wall could not have put on its present appearance by one heating, if it were all actually built previously to the application of the heat. This precludes the possibility of the supposition contained in Mr. Tytler's hypothesis. Had the fire, which he supposes the cause of vitrification, been produced by the burning down of the wooden part of the compound wall which he has imagined, it could not have happened that a vitrification requiring a temperature of 60° should have taken place in one part, while in another such a substance as pyrites remained unchanged. The great heat requisite to effect the vitrification of the pudding-stone, is an additional argument against this hypothesis, as it could not have been produced by any quantity of wood capable of entering into such a wall, unless the wood had predominated to an extent incompatible with any idea we can form of its architecture. It is not indeed easy to conceive a plan capable of producing these effects, and certainly none more feasible than the suggestion of Mr. Williams. With him I should rather be inclined to suppose that a sort of furnace was constructed of a double earthen wall, in which the materials were placed, with such a quantity of wood as was sufficient to excite a strong heat, and that this operation was repeated till the wall had gained its wished for elevation. The earthen furnace in which the Africans fuse their ores, seems to countenance this supposition. The imperfect ustion of the upper parts may be easily conceived to have arisen from a partial neglect of the fire after the wall had nearly attained its requisite height; nor is there any reason why it should not have been increased in height by the addition of cold stones after a firm foundation had been obtained.

One other circumstance in the appearance of the burnt stones is deserving of notice before quitting this subject. The changes which the mica slate has undergone, appear to be such as could not have been produced but by long torrefaction, or by such a repetition of the heat as I have supposed to be the result of design. The transient effects which would follow from burning down a wooden wall, would scarcely have been sensible on stones of so refractory a nature, which exhibit changes in many instances as great as if they had been exposed for a long time to the heat of an ardent furnace.

Such are the observations to which a consideration of the fort of Dun Mac Sniochain has given rise.

As this was the only one of these mysterious fabrics which I had seen when the above remarks suggested themselves to me, I was afterwards glad to have an opportunity of examining the fort on Craig Phadric, it being that one on which most labour had been bestowed, and that which I thought might possibly either confirm or refute my notions on the subject.

Its general appearance and military structure having been fully and carefully described, I shall only indulge in a very few remarks on its physical composition.

The hill of Craig Phadric, on which it stands, is one of a numerous set of pudding-stone rocks, which may be traced from Fyers, and for aught I know, beyond it. At Fyers they lie above the primary rocks, which they doubtless separate as usual from the secondary strata, as they may be seen near Inverness, succeeded by sandstone-breccia and common sandstone. On the top of the rock there is a deep deposit of rounded stones, consisting of fragments of the older rocks. The pudding-stone of Craig Phadric differs completely from that of Lorn. It contains no fragments of the greenstone amygdaloid, there being no greenstone beds in its vicinity, as there are on the Oban coast. The pebbles which it does contain are of quartz, gneiss, granite, and the other associated rocks. The paste which cements them is of a granular texture, entirely and essentially different from that of the Lorn pudding-stone, and belonging to a very different class of substances. It is agglutinated by adhesion, as the sandstones are, without a common binding paste; and consists of fragments of the same rocks which form the nodules, exhibiting generally a gritty mixture of horn-blende, mica, felspar and quartz, with a considerable portion of ferruginous felspar clay. The difference in the vitrification of the wall arising from this cause is obvious, since the scoria of Craig Phadric contain none of that very light and spungy sort capable of floating in water, and which I have shown to arise from the fusion of the calcareous amygdaloid. It differs also in these respects, that it contains no pyritical slate, and that it contains fragments of sandstone. The heat has operated on these stones so as to roast and crack the quartz, granite, gneiss, mica-slate, common slate, and sandstone, producing appearances similar to those of the specimens in Dun Mac Sniochain. The gneiss only which contains much hornblende, and passes into hornblende-slate, is partially fused. The mica-slate, containing also in some instances layers of hornblende, has been split in sunder by the vitrification of these laminæ, and in other cases it is bent and contorted in a very amusing and instructive manner. But the cementation of the wall is produced by the vitrification of the paste which forms the pudding-stone. By this, not only its own pebbles are united, but the neighbouring stones have been entangled in the general mass.

It is plain that no additional argument to support the notion of a design to vitrify can be deduced from this specimen, except that of the great heat required to fuse it, which applies as well to this case as to that of Dun Mac Sniochain.

Having in these two instances detected the existence of a vitrifiable substance in the rocks from which the walls were constructed, I was in hopes that all the other vitrified forts would be found to occur in the vicinity of vitrifiable rocks. No mineralogical notice has accompanied the accounts of those which have been observed in Aberdeenshire, in Ross-shire, and other situations, nor had I an opportunity of inspecting them. But I have since learnt that three or four exist in Arisaik, a country consisting of gneiss and granite rocks only. The refractory nature of these substances would almost lead us to doubt that the buildings are actually vitrified, unless hornblende or other unnoticed vitrifiable matters abound in them.

It is but of late that similar structures have been detected in the southern parts of Scotland. Three of them are found in Galloway; but I had an opportunity of examining only that which lies in the parish of Amworth. It is a rectangular and simple wall, occupying the summit of a steep and strong but low hill, and exhibiting the usual general appearances.

As the whole of this part of the country consists of common grauwacke and grauwacke-slate, I was I confess incredulous about the reported vitrification, on account of the refractory nature of those substances.

On examining the wall, it appeared that although it bore very generally the marks of fire, the vitrification had occurred in very few places and in distant patches. I was at a loss to account for this circumstance, till on accurate examination of the surrounding rocks, I found some places where the grauwacke assumed a peculiar character, exhibiting distinct grains of imbedded carbonate of lime.

This variety is fusible, and from this unquestionably the vitrified portions had originated. It is here that a part of the rock has been cut down, very certainly by sharp tools, for the purpose of scarping one side of the fort. There is no bed of foreign fragments on the top of the grauwacke, and no covering but the common soil. I know not what conjectures we can form about this fort, except that the same attempt has been made, but has failed from the deficiency of proper materials. I confess that the consideration of the requisite heat inclines me as much in this case as in the former to the original supposition, and confirms in my mind the notion that the vitrified forts of Scotland are the effects of design.

Since the above account was written, two circumstances have occurred to me which seem to afford additional evidence of the truth of the opinions I have held respecting the vitrification of these buildings.

The first is an article in the 12th vol. of Nicholson's Journal, p. 313, quoted from the report of a French engineer (M. Legoux de Flaix), describing a method of building practised in Hindustan. In this process a wall of brick earth is erected, which is then surrounded by a coffer filled with combustibles. As the combustion proceeds fresh fuel is added, until the whole wall is baked into one solid brick. The coincidence of the effects of this actually existing process with those of one long since forgotten, seems to prove almost to demonstration, that similar means have been practised in the ancient military works of Scotland to produce structures so analogous to those now commonly used in India, and that the "baking" of buildings in this country must be considered in the light of a lost art.

The other is to be found in the history of Gatacre-house in Shropshire, (now unfortunately pulled down) of which a slight and not perfectly correct account is given by Owen Salisbury Brereton Esq. in the third volume of the Archæologia. On applying to the present most respectable octagenarian proprietor, (descendant of this ancient family,) to whose regard for the superior comforts of a modern house we are indebted for the destruction of this singular and venerable remain, I was informed that the west end alone had been vitrified. The vitrification was so entire and continuous, as to form one uniform glassy surface over the whole of the wall, and thus to conceal even the joints of the masonry. The wall itself was of grey mottled sandstone, about 18 inches thick. I have examined the vitrified crust in a specimen transmitted to me. It is scarcely the twentieth part of an inch in thickness, and consists of a green transparent glass, perfectly superficial. Its appearance would lead me to conclude that it had been produced by the application of alkali or salt to the surface of the wall, previously to the process of firing by which the vitrification was effected. The proprietor is inclined to think that the vitrified wall was of greater antiquity than the rest of the building, but offers no conjecture relative to the time of its erection. It is only known that the family can be traced on the same spot to a period as far back as that of Edward the Confessor.

We have here then additional accessory evidence to prove that the art of vitrifying buildings after their erection, was an art practised in Britain. In this case it was evidently intended for the purpose of excluding the weather, and certainly a more effectual expedient could not have been devised. The vitrified forts of Scotland, more solid and less exposed to the ravages of art, have but partially yielded to the universal enemy, time. The more slender structures intended for habitation, have disappeared in the lapse of years, or have suffered from the taste of other improvers.

IX. *On the Sublimation of Silica.*

By J. MacCulloch, M.D. F.L.S. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich. V. Pr. Geo. Soc.

SOME years ago, being in pursuit of another object, a mixture of the oxides of tin and lead was exposed to the heat of an air furnace in an English crucible, to the top of which was luted another of the same sort. This apparatus was allowed to remain in the fire for some hours. No account of the heat was taken, but I have on former occasions produced in the same furnace a heat sufficient to contract one of Mr. Wedgwood's original clay pieces to the 130th and 140th degree of his scale. On removing the crucibles, the insides of both from the bottom of the lowermost to within a third part of the top of the uppermost, were found covered with white brilliant filamentous crystals crossing each other in all directions. I concluded that they consisted of the oxide of tin, or perhaps that of lead, and subjected them to the obvious experiments necessary for ascertaining this circumstance. Failing to confirm this supposition, I then conjectured that they might consist of silex. The quantity I procured scarcely amounted to half a grain, and I therefore divided it into two parts, that I might have the satisfaction of confirming or refuting my own trials by comparison with those of some chemical friend. Mr. Aikin was so good as to undertake the examination of the reserved portion, and from his well known accuracy, the Society will naturally place confidence in our mutual results. On igniting them in successive portions of borax and of pure potash, they were dissolved. The solution was then neutralized, and a few light flakes fell down, which were redissolved in muriatic acid. This solution being evaporated to a transparent jelly, was ignited by the blowpipe, and became insoluble in acids. I was very desirous of obtaining a second specimen, and repeated the same process many times for that end, but in vain. I can not pretend to account for this accidental appearance, and only regret that I was unable to ensure it at will. There can be no doubt that they were crystals of silica, however difficult we may find it to form them at pleasure, and the rarity of the occurrence only serves to prove that there are properties and relations of this substance with which we are as yet unacquainted. An agreeable confirmation of this fact appeared some time after in an observation of Vauquelin, copied in Tilloch's journal for 1809, with which the members of this Society are doubtless well acquainted. In a geological view it may perhaps be worthy of record as not only establishing the volatility of silica, but serving to prove that this substance may be crystallized from the state of vapour, as sulphur, some neutral salts, and some metals are known to be. How far this property of vaporization and crystallization from that state may be possessed by the other earths, or by earthy compounds, as it undoubtedly is by all the metals, must be determined by future observations. Possibly we may thus gain a step on which to rest, in the investigation of the difficult subject of mineral veins, and the arrangement of the crystallized substances which occupy their cavities. The possibility also of explaining by this process the crystallization of the delicate filamentous zeolites which occupy the cavities of amygdaloids, will readily occur to every mineralogist.

X. *Observations on the Specimens of* HIPPURITES *from Sicily, presented to the Geological Society by the Hon. Henry Grey Bennet.*

By JAMES PARKINSON, Mem. Geol. Soc.

THE examination of the excellent series of Hippurites, from Cape Passaro, in Sicily, presented to the Society by the Hon. H. G. Bennet, has occasioned the present endeavour to add to the knowledge of the nature and œconomy of the animal, whose remains are thus beautifully preserved. The specimens are indeed such as demand, that they should obtain the particular attention of the Society, since they possess those characters which will probably serve to correct some erroneous opinions respecting the nature and habits of the animals of which these shells were the dwellings.

These fossils exactly agree with the description of M. Lamarck, being *straight or bowed conical shells, furnished internally with transverse septa, and with two longitudinal, lateral, obtuse and converging ridges.* These characters are distinctly observable in one of the specimens* which contains, with several other remains of these fossils, a nearly perfect shell, longitudinally divided, so as to display very beautifully the two ridges, with the numerous septa and chambers. In another,† a longitudinal section of one of these fossil shells, the same parts are shewn, and the extreme thinness of the septa, and the closeness with which they are placed to each other, are particularly observable.

* No. 1. of the Series. † No. 2.

M. Lamarck concludes his description of this fossil by saying, that *the last chamber is closed by an operculum* ; a circumstance which M. Picot de la Peyrouse had supposed that he had frequently observed, whilst examining the numerous specimens which he had found on the Pyrenees. The existence of this operculum is however positively denied by M. Denys de Montfort, who considers this supposed operculum as only one of the septa bearing the impression of the posterior part of the animal. Two specimens* contain sections of these fossils, towards their superior termination ; and shew, perhaps, the inner side of this last septum or supposed operculum ; but do not appear to yield any marks which may assist in determining on the real nature and office of these parts.

M. Picot de la Peyrouse, besides finding several of these bodies of a conical form, whose length did not exceed their diameter, found others of a cylindrical form, some of which were a foot and a half in length, though not more than an inch in diameter ; and of course nearly as large at one end as at the other. The regular manner in which he found these fossils arranged by the side of each other led him to describe them as resembling the pipes of an organ. M. Denys de Montfort has thought proper to place the fossils of this description under a new and distinct genus, which he names *Batolites organisans*, (*Le batolite tuyau d'Orge.*) The *hippurite* he remarks is constantly bowed and short, and possesses a very thick shell ; whilst the *batolite* on the contrary is straight and long, and has a very thin shell.

In another specimen† a section of one of these fossils is seen possessing a much greater degree of curvature than that which is seen in No. I. which indeed departs but little from the straight line. These two fossils may be regarded as intermediate in their

* No. 2 & 4. † No. 5.

length and form, between those which have been placed by M. Denys de Montfort in the two different genera, *Hippurites*, and *Batolites organisans;* and if this connection be admitted, it may then appear that those differences which that assiduous naturalist has assumed as the foundation of generic distinction, should be considered as at most only marking the distinction of species.

No attempt has hitherto been made to explain the uses of the several parts of this fossil, or to infer from them any thing respecting the habits of the animal itself. M. Picot de la Peyrouse gives the following observations on the subject: "Nous ne connoissons que très imparfaitement l'analogue marin des Orthocératites. Ceux que Plancus a découverts dans les sables de Rimini, et que Gualtieri a fait graver, grossis aux microscope, suffisent pour convaincre les plus incrédules, que les orthocératites sont de véritables corps marins pétrifiés: mais non pour nous faire connoître l'usage du siphon, de la gouttière, des concamérations, &c. Il faudroit, pour y parvenir, découvrir les analogues marins des principales espèces de grands Orthocératites, avoir étudié leurs mœurs, leurs habitudes, leur manière d'être. Que des difficultés désespérantes ne présente pas ce projet! dût il même être rempli, serions nous, pour cela, mieux instruits de l'usage de cette partie essentielle de l'organisation de cette animal? Le nautile chambré est un des coquillages les plus connus. Nous avons la description, on la voyoit en troupes sur la surface des mers, voguer jusques dans les ports les plus frequentés (voyez description du cap. de B. E. tome III. p. 154); nous savons qu'il a des cloisons, et un siphon; nous n'en ignorons pas moins l'usage qu'il en fait? Je crois donc ne mériter aucune blâme, si je ne hazarde point de conjectures sur l'organisation des différentes parties de ces orthocératites; parcequ'il me seroit impossible de les étayer d'aucune preuve satisfaisante." (Description de plusieurs nouvelles espèces d'orthocératites, &c. p. 15.)

A due attention however to their peculiar organization would, it may be supposed, have prevented the multilocular shells from having been considered as pelagian shells. But M. Denys de Montfort, with most of the French oryctologists, is disposed to believe that all those shells which are known to us only in a fossil state, and which have therefore been supposed to belong to animals which are now extinct, do actually belong to animals which constantly inhabit the bottom of the sea, never rising to the surface, or appearing on the shores. Thus the orthoceratites, ammonites, and belemnites, notwithstanding their possessing different modifications of that organization by which the nautilus is enabled to raise itself to the surface of the water, are all considered as petrified pelagian shells, whose recent analogues have not yet been brought to view. Thus speaking of the *simplégade couleuvreé (simplegades colubratus)*, a fossil shell hitherto considered as an ammonite, but which this author has thought right to place under a distinct genus, he says, " Il est très probable que les simplégades, comme beaucoup d'autres mollusques pélagiens, vivent dans le fond des hauts mers, et qu'une cause physique quelconque ne leur permet point de paroître à la surface des eaux." (Conchologie Systematique, &c. p. 84.)

Having already opposed this opinion in a general way, in my *Examination of the organic remains of a former world;* and having shown that in all the known multilocular fossil shells such an organization existed as was well calculated to enable the animals to raise themselves occasionally to the surface of the water, I shall here endeavour to determine how far the specimens presented to the Society will show, that this property was possessed by the hippurites.

On examining those parts of this fossil, which have been hitherto spoken only of as lateral ridges passing through the chambers and septa, they will be found in most specimens to be formed of a solid spathose substance. But in the specimen No. VI, in which is a transverse section of one of these shells near to its upper extremity, these ridges will be seen, in consequence of the cavities not having been filled by the infiltration of calcareous matter, to have originally possessed a singular organization: a substance of extremely loose and light texture is disposed in plates, which radiate towards the sides of the containing tubes, leaving interstices between them, nearly equal in size to that of the radiating substance itself.

It is indeed impossible to speak decidedly as to the manner in which this peculiar organization could influence the buoyancy of the animal and its dwelling. It is however not difficult to conceive that the animal might possess the power of contracting and of expanding this radiating substance; and might, by thus admitting or expelling the water, produce that change in the specific gravity of the whole mass as might occasion it to sink or rise according as the necessities of the animal might direct.

The great substance of this shell, it being generally about half an inch in thickness, does not, it must be acknowledged, appear at first sight to be favourable to the opinion of its having been capable of being rendered buoyant. But the appearances offered to our observation by the specimen No. VII. give reason for supposing that the texture of the shell was such, that its size might rather promote than prevent its buoyancy. In this specimen the looseness of the texture of the shell is very remarkable; it must however be admitted, that it is difficult to ascertain how much of this depends on the original lightness of structure, the interstices not having been filled up by calcareous matter, and how much on subsequent decomposition.

XI. *An Account of the Coalfield at Bradford, near Manchester.*

By Robert Bakewell,

Communicated to the Geological Society by Dr. Roget, M.G.S.

THE Coalfield which I have undertaken to describe is of very limited dimensions, extending little more than two miles in length, and about 2000 yards in breadth. (See Pl. ii. fig. 2.) The form of its area is oval. The greatest depth to which the workings have been carried is 140 yards. Ten seams of coal rise to the surface, some of which are greatly deteriorated by an intermixture of pyrites. The river Medlock flows nearly at right angles with the line of bearing of the strata and a section is exposed on its banks to a considerable distance.

The strata which alternate with the beds of coal are the same that are usually found under similar circumstances in Lancashire, Cheshire, and the west of Derbyshire, viz. argillaceous and bituminous shale with vegetable impressions, and ironstone sometimes in beds sometimes in nodules. There occurs also over the first coal what is more uncommon, limestone not containing I believe any organic remains; it lies in three several strata from 2 to 6 feet in thickness. It is of a reddish brown colour, and resembles the magnesian variety of Derbyshire in appearance, though it differs from it in its component parts.

The coalfield is bounded (except at its eastern extremity) by red siliceous sandstone, similar to that on which the town of Manchester stands, and it is remarkable that within 15 or 16 yards of its contact with that rock, the coal is soft and hardly worth working. This rock stretches through the south of Lancashire into Cheshire and Shropshire, and appears to agree in some respects with the old red sandstone of Werner. I have been told by a considerable proprietor of coal-mines in these counties, and I believe it is an opinion very generally entertained, that this sandstone always cuts off the coal-measures, and that it is useless to search for coal beyond or beneath it.

The Bradford coalfield appears at first sight to offer an exception to this rule; but upon more attentive examination it will be found, that what covers the coal-measures there is not the rock itself, but only a portion of it, washed down from the higher lands, and spread over the surface.

The coal-measures dip to the south at an angle of about 30°, and wherever they have been proved, on the southern side of the field, abut against the sandstone; but on the northern side, at the distance of ten yards from the red rock, a most striking change in the position of the strata is discovered. A bed of coal, four feet in thickness, here rises up to the surface perpendicularly, and terminates the coal-measures, the intermediate space between this bed and the red rock being filled with broken stones or rubble without any appearance of stratification. This perpendicular bed has been worked to the depth of forty feet, and is of the same quality and general appearance as a four-feet bed which rises near the middle of the field. The stone that lies over the one agrees with that adjoining to the other, which the proprietor does not doubt is a portion of the inclined bed broken off, and thrown into its present position. The distance of the perpendicular bed of coal from the rise of the last bed, that preserves its inclination of 30°, is 325 yards, and between these no fracture or fault has been found to explain the difference in their angles of elevation. There is indeed a dyke in one part of the field, filled with a stone nearly similar to the red rock, but it does not affect the position of the strata on either side of it.

Fourteen hundred yards to the north of the Bradford coalfield, and separated from it by the red sandstone, is the coalfield of Droylsden. The first coal that rises there at the distance of 60 yards from the red rock, is similar to the bed which rises at the distance of 350 yards from the perpendicular coal in the Bradford field.

In the middle figure of Pl. 2.

A A represents the length of the Bradford coalfield.

B B its breadth.

C C C C C. different beds of coal which rise to the surface, and would be visible along their line of bearing parallel to AA, but are concealed by soil and gravel, except on the banks of the river Medlock.

P P the perpendicular bed of coal.

LL the limestone.

R R R the red sand rock.

S S two beds of coal 20 inches thick, one of them situated in Droylsden coalfield.

The lower figure of Pl. 2. represents a section of the same strata on a vertical plane perpendicular to A A.

It appears probable that the strata in these two fields were once united, and have been separated by some convulsion of nature; in consequence of which the red rock has been interposed like a wedge between them, a sliding motion being given to the strata by lateral pressure; for a force acting in a direct line from above or beneath could not produce the bending or folding of the four-feet coal.

The red sandstone has not, I believe, been sunk through in any part of our island, so that its immediate substratum is yet unknown.

If it should prove to be the metalliferous limestone, it will occupy the same geognostic situation as the red shale of Derbyshire and

Yorkshire. There is, generally speaking, a considerable difference in the external characters of these two beds; but at Alderley edge* some parts of the red rock, containing mica, bear a greater resemblance to the shale than I have found in any other situation where I have examined it.

Mr. Whitehurst observed that a species of grit-stone, which he denominates the Mill-stone grit, is found under the coal, but never over it. This bed of rock, which in some situations is not less than 140yards in thickness, varies in quality from a coarse-grained grit, approaching to a breccia, to a fine-grained siliceous sandstone. Some varieties of it are red, and bear a greater resemblance to the sand-rock of Lancashire and Cheshire than the red shale, which lies beneath the mill-stone grit.

It is not improbable that in distant places the same stratum may assume different characters, particularly when it belongs to that class of rocks which have been considered by geologists as mechanically deposited by the action of the tides. Strata thus formed may reasonably be supposed to alter with the materials of which they were made; materials that have been washed from the different parts of extensive ranges of mountains variously composed. I am not aware that this view of the subject has before been taken by geologists, although we may thus account for the gradual transition of rocks into one another, and may often give a more natural solution of the sudden changes we observe, than by the supposition of faults, of whose existence some evidence should always be given, independent of the difficulties which their admission would explain.

In thus comparing the geognostic position of the Red sandstone with that of the Mill-stone grit, I do not wish to advance any opinion of my own as to their identity, but merely to direct the attention of future enquirers to this subject.

* For the account of Cobalt ore contained in the Red rock at this place vide Monthly Magazine, February, 1811.

XII. *Some account of the Island of Teneriffe.*

By the Hon. Henry Grey Bennet, M.P. F.R.S. Pres. Geological Society.

THE island of Teneriffe is the principal island of the seven in the Western Ocean, that are called generally by the name of the Canaries. It lies north-east by south-west, and is in length from the *Punta del Hidalgo* to the *Montana Roxa*, its northern and southern extremities, about 70 English miles; its greatest breadth not exceeding 30. The superficies may be considered as containing 80 square leagues.

The island narrows at its north-eastern and widens considerably at its south-western extremity. About the centre of the latter, or perhaps to describe more accurately, to the westward of the central point, is the mountain called by the Spaniards *el Pico di Tiéde*, but better known by the name of the *Peak of Teneriffe*, and which is the highest land not only in the island, but in all the *Canaries*; the mean of various observations making it 12,500 feet above the level of the sea. It is visible at a great distance; we saw it perfectly distinct thirty-four leagues off by chronometrical observation, when it appeared rising like a cone from the bed of the ocean; and I have heard that it has been clearly distinguished at a distance of 45 leagues.

The rocks and strata of the Island of Teneriffe are wholly volcanic; a long chain of mountains, which may be termed the central chain, traverses the island from the foot of the second region of the

Peak sloping down on the eastern, western, and northern sides, to the sea. Towards the south, or more properly the S.S.W. the mountains are nearly perpendicular, and, though broken into ridges and occasionally separated by deep ravines that are cut transversely as well as longitudinally, there are none of those plains nor that gradual declination of strata that the south-eastern and north-western sides of the island exhibit.

From the *Barranco Seco*, in the neighbourhood of *Santa Cruz*, to the northerly point called *Punta del Hidalgo*, a series of steep and abrupt mountains form headlands to the sea, separated from the central chain by the valley of *Laguna*; these mountains are rugged and peaked, drawn up, if the term may be used, in a column, and are divided by deep ravines. The sides of these mountains are steep, being in many places cut nearly perpendicular to the horizon, and are all composed of lava generally of the basaltic formation, mixed with beds of tufa and pumice. From *Hidalgo* point to that of *Teno*, the most westerly point of the island, the strata vary from beds of pumice and decomposed lava and ash, which form the plains of *Laguna Ticaronte* and *Songal*, to streams and currents and headlands of lava similar to those of the *Barranco Hundo*, *San Ursula*, *Las Horcas*, *and Las Guanchas*. The slope from the central chain is here gradual, intersected by ravines and streams of lava. The soil famed for its fertility and which produces the Teneriffe wine, is composed of lava and ash in a state of decomposition. Headlands, some of them from two to three hundred feet in height, project into the sea between *San Ursula* and *Orotava*, forming perpendicular cliffs. At the western extremity of the island from *Punta di Teno* to *Puerto de los Christianos*, the strata rise in a broken ridge to the Peak, the land ascending gradually from *Punta de Teno* by a chain of small peaked hills; the point itself being very low and projecting as a promontory into the sea. The declination of the strata is similar from the Peak to *Puerto de los Christianos.* This south-westerly chain is broken into many abrupt ridges, and is cut nearly perpendicular down to the sea. I could not perceive any base or shelf as on the other sides of the Peak, from which the cone arose, but the fall is regular though steep. From *Puerto de los Christianos* to Santa Cruz, comprising the southern and south-eastern sides of the island, the form is similar to that in the vicinity of *Orotava*, but it is barren and desolate, laid waste by streams of lava. In the short space of a few leagues I counted no less than seven cones of extinct volcanoes, and the country is covered with scoria, exhibiting no appearance of culture, and hardly any of vegetation ; it is more broken into ravines and more intersected by lava torrents than on any of the other sides of the island. Numerous peaked and conical mountains rise upon the slope of the chain, and the whole country is covered by scoria, and is one continued stream of lava. The *Montana Roxa* itself is a singular example of the dislocation of strata so commonly found in countries of volcanic formation ; it is evidently a slip or fall of semi-columnar lava, and slopes into the sea at an highly inclined angle.

The ordinary strata of the island are as follows, reckoning from below upwards : 1st. the porphyritic lava covered by scoria and sometimes by pumice. This lava is composed of hornblende and feldspar, and contains no other substance. The next stratum graduates into what the Spaniards call *Roccaverde* or *greenstone*, and is composed of feldspar and hornblende ; upon this is generally a thick stratum of pumice, and last of all towards the surface is the basaltic lava covered also by tufa and ash. This lava decomposes the soonest. It also contains the greatest variety of extraneous substances, and is sometimes divided by a layer of large crystals of olivine some inches long, and towards the north-east is often intersected by strata of porphyritic slate. These lavas are more earthy and cellular than those which I have had an opportunity of observing elsewhere, yet they contain fewer extraneous substances than those of Ætna and Vesuvius; they are in some places exposed to view in the vallies similar to those of the *Corral* in the island of Madeira. The valley of *Las Guanchas* on the north-west side of the Peak, contains according to M. Escolar* above 100 strata of lava, the one reposing upon the other, at times alternating with pumice and tufa. The depth of these strata varies. M. Escolar has seen one of basaltic lava between 100 and 150 feet in depth in one solid mass, cellular at the surface, but gradually becoming more compact towards the bottom. This basaltic lava contains olivine and hornblende, and, in the caves on the coast, zeolite. This substance is also found in stalactites and in masses, sometimes in layers spread between the strata and diffused over the rock.

Nodules of chalcedony are sometimes also found, but these substances occur only in the chain of mountains towards the north-east, from the northern extremity of Santa Cruz to the point of Hidalgo.

The lavas of the island are of an endless variety, and the number of streams that have flowed are much beyond all enumeration. The whole surface is either ash, or solid or decomposed lava, which seems again and again to have been perforated by volcanic eruptions; the number of small extinct volcanoes is prodigious, they are to be found in all parts of the island, but the stream that has flowed from even the largest of them, such as the lava of the Peak called *el Mal Pais*, is trifling in comparison with that immense mass of lava mountains

* M. Escolar was sent out by the Spanish government to examine the political, commercial and mineralogical state of the Canaries; he has well performed his task, and it is to be regretted that the situation of his native country has hitherto deprived the public of the interesting facts he is able to communicate.

which constitute the central chain of the island, and which stretch out as headlands like those of *las Horcas* and *San Ursula.*

I never found in situ those masses of columnar basaltic rock that are so common in the island of Madeira : but in the valley of *las Esperanzas*, in the chain of hills to the north-eastward of the town of Santa Cruz, they lie scattered about in considerable numbers, and M. Escolar told me that he had seen strata of them to a considerable extent, exhibiting with precision the columnar basaltic form; the modern lavas of the peak are all basaltic, that of 1704 is decidedly so, as well as that of 1798, though not exhibiting any prismatic form. Prisms of basaltic lava are yet found on the peak: I picked up one, though there are no strata of them to be met with. The metals are rare, and afford but little variety: specular and micaceous iron, black and grey manganese are all that have hitherto been discovered. The salts that are so common on Vesuvius, are here seldom met with. Augite is also rare, and mica and leucite, though carefully sought after, have hitherto not been found.

In that part of the island between *Laguna* and *Tacaronte*, where there are few streams of lava, the soil is evidently volcanic. I examined many of the clods that were turned up by the plough, and found them all alike: they contained much strong clay, with crystals of feldspar, olivine, and specular iron. Dr. Gillan, who accompanied Mr. Barrow and Sir G. Staunton, has advanced an opinion, that between *Laguna* and *Matanzos* there are no signs of volcanic formation. That the currents of lava occur but seldom is most true; but the mountains in the vicinity of Laguna are all volcanic, and one has a visible crater; besides, the assertion would prove too much; for it would go to maintain that the Campagna Felice, as well as the plains of Catania, were not created by the ash and pumice eruption of Vesuvius and Ætna. The bed of soil is here very deep. I examined some ravines that the rains had laid open to the depth of 30 or 40 feet: the strata were indurated at the bottom, and resembled the tufa in the vicinity of Naples, and all contained the substances mentioned above. This tufaceous character changes as you ascend the hill that separates Laguna from Santa Cruz; the hill itself, and the whole neighbourhood of the latter city is one continued stream of lava, hardly at all decomposed, with little or no vegetation; but here and there in the hollows some few stunted plants of the aloe algarvensis, and the cytisus.

Having given a general account of the island, I shall now attempt to describe the country of the peak, which mountain I ascended on the 16th of September, 1810. The road from Puerto Orotava to the city of Orotava, is a gradual and easy slope for three or four miles, through a highly cultivated country. The soil is composed of volcanic ash and earth, and to the eastward of the town of Puerto di Orotava are the remains of a recent volcano, the crater and cone being distinctly visible. Leaving the town of Orotava, after a steep ascent of about an hour through a deep ravine, we quitted the cultivated part of the slope or valley, and entered into a forest of chesnuts; the trees are here of a large size. This forest of chesnuts is mixed with the erica arborea, or tree heath, which shrub rises to the height of 18 or 20 feet. Some of the stems are as thick as the arm of a man, joined together in bunches or tufts like the common heath. The form of this forest is oblong, it covers the flank of those hills which I have already denominated the central chain, from their summit to half their elevation from the plain. The soil here is deep, and formed of decomposed lava, small ash, and pumice. I examined several channels in the strata or ravines worn by the rains, and there was no appearance of any other rock. Leaving this forest, the track passes over a series of green hills which we traversed in about two hours, and at last halted to water our mules at a spot called *el barranco del pino de la meruenda*, where there is a small spring of bad and brackish water issuing from a lava rock. The ravine is of considerable depth. After the vegetable earth, which is 2 or 3 feet deep, a layer of tufa succeeds, which is followed by a lava of a greyish-blue colour, 30 or 40 feet in depth. It is compact, contains olivine, and the strata lap over each other, but shew no appearance of columnar formation. The range of green hills extends a mile or two further, the soil shallowing by degrees, more lava and scoria shewing themselves on the surface, the ravines or channels, worn by the rains, becoming more common, the trees and shrubs gradually dwindling in size, and of them all the Spanish broom alone at length covers the ground. Leaving behind us this range of green hills, the track still ascending leads for several hours across a steep and difficult mass of lava rock, broken here and there into strange and fantastic forms, worn into deep ravines, and scantily covered in places by a thin layer of yellow pumice. The surface of the country, for miles and miles around, is one continuous stream of lava; the rents or ravines of which seem to be formed partly by the torrents from the hills flowing for so many ages, and partly from that tendency, characteristic of a lava current, to keep itself up in embankments, and in its cooling process to open out into those hollows which I have uniformly found in every eruption of lava that I have had an opportunity of examining. This lava is cellular beyond any I have ever seen, is of a clayey earthy porphyritic composition, and contains few, if any, pieces of olivine, though here and there felspar in a semicrystallised form. As we proceeded on our road, the hills on our left, though broken at times in deep ravines, gradually rose in height till the summits were lost in those of the central chain, while on our right we were rapidly gaining an elevation above the lower range of the peak. This range forms one flank of the plain or valley of *Orotava*, stretching from south-east to north-west, and is broken into steep precipices, cut down in some places perpendicular to the horizon, and called *las Horcas:* it joins the central chain at the high elevation of the pumice plains, sweeps down the side of the valley, and forms a headland near 200 feet high, projecting into the sea, some miles from *Orotava;* we traversed this country an hour or two, till we reached the point of intersection of *las Horcas* with the plains of pumice. On the road are several small conical hills or mouths of extinct volcanoes, the decomposed lava on the edges of these craters having a strong red ochreous tint; by degrees the lava becomes more and more covered by a small ash, and the masses or heaps of pumice gradually increase, till the surface is completely concealed. At length an immense undulated plain spreads itself like a fan, on all sides, nearly as far as the eye can reach, and this plain is bounded on the west south-west, and south south-west, by the regions of the peak; and on the east and north-east by a range of steep perpendicular precipices and mountains, many leagues in circumference, called by the Spaniards *Las Faldas*. M. Escolar informed me that the wall could be traced for many leagues, the whole circumference of which evidently formed the side of an immense crater. This tract, called *Las Canales*, contains, according to the same authority, 12 square leagues. As we entered this plain from the south-west, there are to be seen several declivities of lava and strata, broken inwards towards the plain, and evidently a continuation of the above-mentioned line of wall and the remains of the original crater. There is here no appearance of columnar formation, the lava being earthy and porphyritic; this continuity of wall, at present so easy to be traced, may be considered as forming the sides of one immense crater, from which perhaps originally the lavas of the island flowed, which might have thrown up the cone of the peak, and covered these wide-spreading plains or *clanuras* with the deep beds of ashes and pumice. On this plain or desart, for we had long left all shew of vegetation, except a few stunted plants of Spanish broom,a sensible change was felt in the atmosphere; the wind was keen and sharp, and the climate like that of England in the months of autumn. All here was sad, silent, and solitary. We saw at a distance the fertile plains on the coast, lying as it were under our feet, and affording a cheerful contrast to the scenes of desolation with which we were surrounded; we were already 7 or 8000 feet above the level of the sea, and had reached the bottom of the second region of the peak. Immense masses of lava, some of them many hundred tons in weight, lie scattered on these pumice plains. Some are broken by their fall, and all wear the appearance of having been projected by volcanic force. Their composition is uniformly porphyritic, with large masses of feldspar; the whole compact and heavy, and bearing no resemblance to the earthy lava we had seen in such abundance prior to our entering these pumice plains. Many of these masses are completely vitrified, while others only shew marks of incipient vitrification; but from their site and fracture, from the insulated state in which they lie, from there being no appearance of lava in a stream, from the pumice bed being very deep, (and in one place I saw it exposed to a depth of between 20 and 30 feet) from all these facts taken together, there can be little doubt that these masses were thrown out of the mountain when that lava flowed, which is of similar substance, and which is called by the Spaniards *El Mal Pais.*

Having reached the end of the plain we found ourselves at the bottom of a steep hill, at the foot of which is a mass or current of lava which has flowed from the higher regions of the peak, and which constitutes the eastern branch of the lava of *Mal Pais*. We began to ascend this steep and rapid part of the mountain which is composed of a small white or yellowish ash mixed with masses of pumice and fragments of lava similar to that found in the plains, of which several small pieces that I picked up were in a state of vitrification. After a laborious not to say hazardous ascent of about an hour, the pumice and ash giving way and the mule sinking knee deep at each step, we arrived at about five in the afternoon at the other extremity of the stream of lava, which descending from the summit of the second region of the peak divides at the foot of the cone into two branches, the one running to the north-east and the other to the north-north-west; at the extremity of this latter are several immense blocks or masses of lava which bear the name of *La Estancia di los Ingleses*, and are rocks, not caves as has been stated by some writers. It was here we were to pass the night, so, lighting a fire made of the dry branches of the Spanish broom and stretching part of a sail over a portion of the rock, we ate our dinner and laid ourselves down to sleep. I however passed the best part of the night by the fire, the weather being piercing cold; as I stood by the fire the view all around me was wild and terrific, the moon rose about ten at night, and though in her third quarter gave sufficient light to shew the waste and wilderness by which we were surrounded: the peak and the upper regions which we had yet to ascend towered awfully above our heads, while below, the mountains that had appeared of such a height in the morning and had cost us a day's labour to climb, lay stretched as plains at our feet; from the uncommon rarity of the atmosphere the whole vault of heaven appeared studded with innumerable stars, while the valleys of Orotava were hidden from our view by a thin veil of light fleecy clouds, that floated far beneath the elevated spot we had chosen for our resting place; the solemn stillness of the night was only interrupted by the crackling of the fire round which we stood, and by the whistling of the wind, which coming in hollow gusts from the mountain, resembled the roar of distant cannon.

Between two and three in the morning we resumed on foot our ascent of the same pumice mountain, the lower part of which we had climbed on horse-back the preceding evening; the ascent became however much more rapid and difficult, our feet sinking deep in the ashes at every step. From the uncommon sharpness of the acclivity we were obliged to stop often to take breath; after several halts we at last reached the head of the pumice hill at its point of intersection with the two streams of lava, the direction of which I have before described. This is the commencement of that division of the mountain called *el Mal Pais*; after resting some short time here, we began to climb the stream of lava stepping from mass to mass, the ascent is steep, painful and hazardous, in some places the stream of lava is heaped up in dykes or embankments, and we were often obliged to clamber over them as one ascends a steep wall, this lava is of the same porphyritic appearance as the masses we found in the plains, it is not covered with a thick scoria, and seems never to have been in a very fluid state, but to have rolled along in large masses. The felspar is crystallized in the lava itself, which is slightly cellular at its surface, yet though I searched carefully I was unable to discover any extraneous substance. The whole composition of the stream seems to be felspar imbedded in a brown clayey paste, remarkably hard, of a close texture and heavy; judging from the sharp declivity of the mountain it appears surprising that the lava should have flowed so short a distance; as it does not exceed $2\frac{1}{2}$ or three miles from the base of the cone to the point of union with the pumice hill; the mass of lava as well as its depth is prodigious; M. Escolar told me that its greatest breadth was above two miles, its depth it is not easy to determine, there are however several ravines or valleys in the course of the stream, some of which may be from 60 to 100 feet deep. The fusion of the mass does not appear to have been perfect; it is very earthy, and though vitrified pieces are found, there is no general appearance of vitrification; there are some pieces that exhibit an union with the pumice and the gradation from the stony structure to the vitrified, and thence to pumice. Immense heaps of this latter lie scattered on the surface of the lava, some of them containing large crystals of felspar, which abounds in, or more properly forms the constituent part, of the lava of the *Mal Pais.*

We halted several times during the ascent, and at last reached a spot called La Cueva, one of the numerous caves that are found on the sides of the mountain; this is the largest of them, and is filled with snow and the most delicious water, which was just at the point of congelation, the descent into it is difficult it being thirty or forty feet deep. One of our party let himself down by a rope, he could not see the extent of the cave, but the guides declared it to be 300 feet in length and to contain thirty or forty feet of water in depth, the roof and sides are composed of a fine stalactitic lava similar to that found on Vesuvius, and it is of the same nature as that which flowed on the surface. We rested here about half an hour, during which we had an opportunity of observing the rising of the sun and that singular and rapid change of night into day, the consequence of almost an entire absence of twilight. As we ascended the north-east side of the mountain this view was strikingly beautiful, at first there appeared a bright streak of red on the horizon, which gradually spread itself, lighting up the heavens by degrees, and growing brighter and brighter till at last the sun burst forth from the bed of the ocean, gilding as it rose the mountains of *Teneriffe* and those of the great *Canary*; in a short time the whole country to the eastward lay spread out as a map, the great Canary was easily to be distinguished and its rugged and mountainous character, similar to that of the other islands, became visible to the naked eye. The cold at this time was intense, the wind keen and strong, and the thermometer sunk to 32 degrees; after a short though rapid ascent we reached the summit of the second stage of the mountain, we passed over a small plain of white pumice on which were spread masses of lava, and at length arrived at the foot of the cone. This division of the mountain forms what is generally termed the *Peak of Teneriffe;* it resembles the present crater of Vesuvius, with this difference, however, that while the surface of that mountain is composed of a black cinder or ash, the superficies of this appears to be a deposit of pumice of a white colour, of scoria and of lava, with here and there considerable masses that were probably thrown out when the volcano was in action. Towards the north-west on the right hand of our ascent, there is a small current of lava shewing itself above the pumice, the composition of which is similar to that at the bottom, though of a redder tinge; it is broken on the surface and is in a rapid state of decomposition. Numerous small cavities on the side of the mountain emitted vapour with considerable heat. Here begins, in my opinion, the only fatiguing part of the ascent; the steepness of the cone is excessive, at each step our feet sunk into the ash, and large masses of pumice and lava rolled down from above; we were all bruised and our feet and legs were cut, but none materially hurt; at last we surmounted all difficulties and seated ourselves on the highest ridge of the mountain. This uppermost region does not appear to contain in superficies more than an acre and an half, it is composed of a lava similar to that on its sides, though decomposed and changed white or grey by the action of the sulphurous acid; this acre and an half is itself a small crater, the walls of which are the different points on which we sat, and are plainly visible from below. Within, the lava is in the most rapid state of decomposition; losing its brown colour and shade of red, and acquiring a whitish grey almost the colour of chalk; large masses of sulphur are depositing, which are crystallized in minute though distinct forms; there is also a coating of alum produced by the union of the sulphurous acid with the argil of the lava; the surface is hot to the feet and the guides said it was dangerous to remain long in one spot; as it was, some of us sunk to our knees in the hot deposit of sulphur; upon striking the ground with the feet the sound is hollow, similar to what is produced by the same impulsion on the craters of *Vesuvius* and *Solfaterra.* I estimate the depth of the crater to be, from the highest ridge to the bottom, about 200 feet forming an easy and gradual descent, the whole being in a state of rapid decomposition, and charged with sulphur, large masses of which are every where depositing. I searched in vain for any of the arseniats so common on Vesuvius, nor could I find those siliceous stalactites resembling strung pearls, which are met with in the island of *Ischia*, in the crater of the *Solfaterra*, and in the *Maremma* of *Tuscany.* The sulphur is pure and fine, and is sold for a considerable price at Orotava. We were not able to go all round the walls or exterior summit of the crater, and hence could not distinguish its southern or western declivity; M. Escolar assured me they are similar to, though more rapid than the side by which we ascended; from this side flowed the basaltic lavas of 1704, and of the last eruption in 1797; this latter stream of lava flowed in a remarkably slow current, for notwithstanding the sharp descent of the mountain, and the length of the lava not exceeding three miles, several days elapsed before it reached the spot where it stopped; how little fluid this lava must have been is evident, when it is remembered that the lava of Vesuvius in 1794, which destroyed Torre del Greco, reached the sea from the bottom of the cone, a distance of eight miles, in little more than six hours. M. Escolar further told me that there is on this south-western side of the Peak an ancient lava, at present not at all decomposed, of several miles in length, and in a perfect state of vitrification; the whole of this stream has the appearance of obsidian. All these lavas appear to have flowed from the bottom of the cone, and to have run from its base in the same manner as that of Vesuvius in 1794, the crater of which vomited out ash and pumice, and large pieces of rock, while the current of lava issued from its side. It is not however improbable that the cone itself is of anterior formation to this vitrified lava, as the summit of the Peak is similar to the lava of the *Mal Pais*, and that being porphyritic is considered as of more ancient date than the one above mentioned, which is basaltic.

If one might hazard a conjecture upon a subject where the data are so few, I should be inclined to suspect that the Peak itself, as well as the whole of the country around it which forms its base, were produced by that immense crater called *Las Canales*, the shape and magnitude of which I have before taken notice of when traversing the pumice plains; it is also well worthy of remark that there is no volcano in action at all to be compared in size of crater to those that are extinct. The ancient crater of Vesuvius is considerably larger than the present, and those in the vicinity of Naples, the eruptions of which probably created that district of Italy, are of enormous extent. The crater of the *Camaldoli* is somewhat more than two leagues in circumference, and the superficies of the *Canales* is estimated at 12 square leagues. These vast craters were probably capable of ejecting from their bosom those stupendous beds of lava, which being so much more extensive than any that have flowed from more recent eruptions have led some persons to deny the former to be the effects of a central fire. That all the Island of Teneriffe was volcanically produced no man who examines it can have any doubt, and though the smallness of the existing crater of the Peak may lead one to imagine that it alone could not be the effective cause of all the phenomena, yet the innumerable volcanoes on all sides of the island, the appearance of *Las Canales*, and its elevation, are able to account for the extent of the streams and beds of lava and of the deposits of tufa and pumice, of which the island is composed. Having no data to proceed upon but what is given by the measurement of the eye, it is not easy to determine the magnitude of the cone at its base ; one may say at a venture, it is about three miles in circumference, though towards the S.S.W. the descent is much more abrupt, and the plain from which the cone springs not perceptible. The view from the summit is stupendous, we could plainly discover the whole form of the island, and we made out distinctly three or four of the islands, which together are called the Canaries ; we could not however see *Lancerotte* or *Fuerteventura*, though we were told that other travellers had distinguished them all.

From this spot the central chain of mountains that runs from southwest to north-east is easily to be distinguished. These with the succession of fertile and woody vallies, commencing from *San Ursula* and ending at Las Horcas, with the long line of precipitous lava rocks that lay on the right of our ascent, and which traverse that part of the island, running from east to west from their point of departure at the *Canales* to where they end in an abrupt headland on the coast, with their forests and villages and vinyards, the port with the shipping in the roads, the towns of Orotava with their spires glittering as the morning sun burst upon them, afforded a chearful contrast to the streams of lava, the mounds of ash and pumice, and the sulphurated rock on which we had taken our seat. The sensation of extreme height was in fact one of the most extraordinary I ever felt, and though I did not find the pain in my chest arising from the rarity of the atmosphere, near so acute as on the mountains of Switzerland, yet there was a keenness in the air independent of the cold that created no small uneasiness in the lungs. The respiration became short and quick, and repeated halts were found necessary. The idea also of extreme height was to me more determinate and precise than on the mountains of Switzerland; and though the immediate objects of vision were not so numerous, yet as the ascent is more rapid, the declivity sharper, and there is here no mountain like Mont Blanc towering above you, the 12,000 feet above the level of the sea appeared considerably more than a similar elevation above the lake of Geneva. We remained at the summit about three-quarters of an hour, our ascent had cost us a labour of four hours, as we left the Estancia at ten minutes before three and reached the top of the peak before seven; many indeed of our halts were needless, and M. Escolar told me that he had twice ascended to the summit in somewhat less than three hours. Our thermometer which was graduated to the scale of Fahrenheit was during our ascent as follows: at *Orotava* at eight in the morning, 74°; at six in the evening at *La Estancia*, 50°; at one in the following morning 42°; at *La Cueva* at half-past four 32° ; at the bottom of the cone 36° ; at the top of the Peak one hour and a half after sun-rise 38°. The descent down the cone is difficult from its extreme rapidity, and from the fall of large stones which loosen themselves from the beds of pumice. Having at last scrambled to the bottom, we pursued our march down the other course of the lava, that is to say down its westerly side, having ascended its eastern. The ravines and rents in this stream of lava are deeper and more formidable; the descent into them was always painful and troublesome, often dangerous, in some places we let ourselves down from rock to rock. I can form no opinion why there should be these strange irregularities in the surface of this lava; in places it resembles what sailors term the trough of the sea, and I can compare it to nothing but as if the sea in a storm had by some force become on a sudden stationary, the waves retaining their swell. As we again approached *La Cueva* there is a singular steep valley, the depth of which from its two walls cannot be less than 100 to 150 feet, the lava lying in broken ridges one upon the other similar to the masses of granite rock that time and decay have tumbled down from the top of the Alps ; and, except from the scoria or what Milton calls " the Fiery Surge," they in no degree bear the marks of having rolled as a stream of liquid matter. This current like that of the eastward branch has no resemblance to any lavas I have seen elsewhere, it is hardly at all decomposed, full of laminæ of feldspar, the fracture conchoidal, and the texture porphyritic, the colour brown like that of the other branch ; it is but slightly cellular, and contains no extraneous substances.

We descended the pumice hill with great rapidity almost at a run, and arrived at La Estancia in little more than two hours. We then mounted our mules, and following the track by which we had ascended the preceding day, we reached about four o'clock the country house of our hospitable friend Mr. Barry.

The difficulties of this enterprise have been much exagerated, the ascent on foot is not a labour of more than four hours at most, and the whole undertaking not to be compared in point of fatigue to what the traveller undergoes who visits the Alps. That the ascent must be hazardous in a storm of hail and snow there can be no doubt, but to cross Salisbury plain may sometimes be dangerous. Yet stripped of poetical terrors and divested of the eloquent description of some writers, there is perhaps no mountain in Europe, the ascent of which does not furnish more difficulties than the Peak of Teneriffe.

XIII. *On the Junction of Trap and Sandstone, at Stirling Castle.*

By J. Mac Culloch, M.D. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich.
V. Pr. Geo. Soc.

I HAVE herewith transmitted a sketch of one of those circumstances in the mutual relation of greenstone and sandstone, from which the Huttonian theory is presumed by its advocates to derive so material a support. The particular instance, of which this sketch is intended to give a general notion, has been lately brought to light, and has not, as far as I know, been observed by the geologists of Edinburgh. It does not indeed differ so greatly from the same class of facts in the neighbourhood of that city, as to require very particular attention; but I have been induced to preserve this notice, and drawings of it, (Pl. 12, 13) partly on account of its decided and clear disposition, and partly, lest the same operations by which it was first exposed, may, at no distant period, again remove or overwhelm it. Nevertheless, it may have its use in extending the analogy between those classes of rocks in which this appearance is found, and in rendering it probable that the same cause, whatever it was, presided at the formation of all similar phenomena.

The rock on which Stirling Castle is built, and on which the town also is founded, resembles so strongly that on which Edinburgh stands, that it would be superfluous to describe it very particularly.

It forms a large stair, having its escarpement towards the west, and its inclination similar to that of the great rocks which are not only found in the vicinity of Edinburgh, but are to be seen rising above the general level through the whole interval between Edinburgh and Stirling. The hill of Stirling, and that of Craig Forth, are, I believe, the most western of this class of rocks, which are connected here, as at Edinburgh, with the coal district.

It was in cutting a new road through the castle hill that the appearance in question was laid bare.

The trap stratum consists of a dark blueish black compact greenstone, varying to umber brown, and it is accompanied by tufo ; but the former alone is in contact with that part of the sandstone stratum which is exposed.

On inspecting the drawing, it will be seen that the sandstone stratum has been split into two parts in the direction of its stratification. The upper portion is then separated by a perpendicular fracture, and bent upwards, terminating abruptly. It is in this position involved, supported, and covered by the greenstone. The broken end is irregularly fractured, but all its cavities are perfectly filled up with greenstone. The different laminæ of which the sandstone stratum is composed, are not broken to accommodate themselves to this new position, but are irregularly waved and bent, preserving their continuity every where.

A little additional disturbance appears on the lower side of the bent portion, as if formed by the separation of fragments ; but the drawing will render the appearance more intelligible than any description could do. The state of the rock did not, when I was there, allow me to examine the other portion of the upper part of the bed from which the broken end had been disrupted : future operations on the rock may hereafter lay bare further portions to illustrate this interesting appearance.

The sandstone bed itself consists of different laminæ, varying in colour, but generally slate-coloured, yellowish, and grey. The two lowermost and thickest beds differ little or nothing in texture, colour, or quality, from ordinary calcareous sandstones, and they are (as the drawing shews) of considerable thickness compared with those which immediately follow them.

These thinner beds are separated from each other by laminæ, of a clay slate, very much confounded with the sandstone, and those two substances alternate frequently and irregularly, till they approach the thicker beds which lie in contact with the greenstone. As they approximate to it they become more indurated, and assume a texture approaching to that of hornstone. The lowermost of the two upper beds thus exhibits a kind of hornstone of which the fracture is occasionally granular, and occasionally passes into the splintery and conchoidal. The uppermost bed exhibits the characters of perfect hornstone. It is of an ochre-brown colour, its fracture is conchoidal, or splintery, with an even shining surface, and the thin fragments transmit light.

As the specimens are before the Society, I need not enter into more minute details, particularly as, if taken together with the drawing, they will shew the regular gradation from the ordinary calcareous sandstone to the perfectly characterized hornstone. I may just be allowed to point out the resemblance which this change bears to that gradation from sandstone to a jaspideous rock, which occurs in a similar situation at Salisbury Craig. Considering merely the mechanical position of the sandstone, I confess myself unable to comprehend how by any combination of accidental abrasion or fracture, and successive deposition by precipitation, the present, and similar appearances can be produced. Although the projecting portion of the sandstone might have been able to maintain its place during the deposition of the greenstone bed, yet some other expedient must be resorted to before the curvature of the sandstone stratum can be accounted for. The explanation afforded by the Huttonian hypothesis is too apparent to require notice.

Whether this hypothesis be esteemed well founded or not, it must rest on a much wider basis than that of the mere phenomena which accompany the trap rocks. But if we consider those rocks with the appearances which I have now described, and which they so often exhibit, we may safely conclude that no hypothesis is competent to explain geological phenomena at large, which does not admit of the forcible displacement of the strata which accompany them, and on which the marks of violence are so evidently impressed.

XIV. *On the Economy of the Mines of Cornwall and Devon.*

By John Taylor, Mem. Geol. Soc.

THE miners of many countries have engaged the care and attention of their governments, and have received support from national treasuries, or grants and immunities operating in favor of such undertakings. In some instances officers regularly educated to the profession of mining, are appointed and paid by the state for managing the executive departments. With such advantages it is probable that poorer mines may be worked, than in countries destitute of them, and where they must be undertaken entirely at private risk; yet it is found that the enterprize and ingenuity of individuals is equal to very considerable efforts, and that their calculations of real profit are often more unquestionable than in government undertakings.

If the spirit which is excited by the prospect of gain can be infused into a great portion of the persons employed on any object of this sort; and if the interest of the proprietors of mines can be made to go hand in hand with that of their workmen in their operations, a great degree of united effort may be reasonably expected to follow such a system, which being advantageous to all parties in proportion to their exertion, enlists at once their combined efforts into the service of the common good.

The mines of England have no assistance from the government, but must rely for their success upon their own resources, and the spirit and energy of their owners; and it is probably to this cause that we may attribute the activity and economy which, when their constitutions are duly examined, may be found to prevail in the principal mining districts.

The peculiar system invented and gradually improved to its present state in the mines of Cornwall, and more recently adopted in the undertakings of the same kind in the adjoining county, so completely answer the purpose of combining the interests of the working miner with those of his employer, that if benefit is to be expected from such a plan, it is worth describing, as a detail which may furnish hints that may prove useful to all who are interested in the subject.

The economy of a mine may be considered under the following general heads:

1.—The nature of the agreements between the owner of the soil and the mine adventurers.

2.—The arrangements between the partners or adventurers themselves, and the system of controul and management appointed by them.

3.—The mode of employing and paying the miners and workmen, in use among the agents of the principal concerns.

4.—The purchase of materials for carrying on the undertaking.

5.—The sale of the ores from the mine adventurers to the smelting companies.

In reviewing the whole system, it may appear that there are parts subject to censure as well as others worthy of imitation; but the detail will not be the less useful on this account, and it is to be understood that different mines in the Stannaries vary from each other in these respects, and of course some may be said to be more perfect than others.

The result however of the whole has been the execution of works of extraordinary magnitude, with unparalleled dispatch; the pursuit of the difficult task of discovery with the greatest effect, and a vast increase in the produce of the metals, more particularly of copper, in the last fifty years.

The mines of Cornwall have furnished such supplies that the British manufacturers are no longer dependent on other countries for an article of raw material of the first importance to their trade, while in the space of less than a century, an increase, amounting to the annual value of near a million sterling, has made England one of the sources whence the world is now supplied with copper, instead of relying for this article upon the mines of Germany or Sweden.

1. *The Nature of the Agreements between the Owner of the Soil and the Mine Adventurers.*

The grant for working a mine is called a *set*, and is usually taken by one or more persons from the proprietor of the land in which a load may be found, except in such cases of tin-mines as are anciently *embounded* according to the provisions of the stannary laws, whereby a right of working for this metal is obtained. No custom or ancient law however prevails as to copper or lead in the stannaries, and therefore all agreements for searching for, or working these metals, are made upon such terms as are decided on by the contracting parties. The owner of the land, in the technical language of the district, is called the *lord*, and the parties who engage to work the mine are called *adventurers*.

The lord grants a lease or set for 21 years, reserving a power to put an end to the term, if the mine should not be effectually worked; he likewise agrees for a certain proportion of the ores to be delivered to him on the mine in a merchantable state, or their value in money: he provides for a power of inspecting the works at all times, and binds the adventurers to maintain and leave at any determination of their grant all the shafts, adits, and levels, perfect, and in good condition, as to timber, where required.

The proportions of ore paid to the land-owner, called the *lord's dues*, vary considerably, according to the circumstances of different mines, and the nature of the prospects under which they may be undertaken. A deep old mine which has been abandoned, is undertaken with a chance of less profit and a certainty of greater risk, than a new and promising discovery. In the first case encouragement is often held out, by fixing very moderate dues, while in the other, so much is too frequently demanded and given, as to prevent that share of profit accruing to the adventurers which is due to the great risk constantly attendant on all mining pursuits.

In the deep expensive mines the lord's dues do not often exceed a fifteenth or eighteenth part of the whole produce of ore, and sometimes they do not amount to more than a twenty-fourth, or even a thirty-second proportion.

In the newer mines the dues are often as much as a tenth or twelfth part of the produce, and there are mines which pay an eighth; but this is the case only in such as were undertaken when the prices of metals were much higher than at present, and where an unusual produce has enabled the concerns to exist in spite of such a heavy deduction from their produce. The dues are delivered to the lord, or to his agent on the mine, free of all expense, or are commuted for a proportionate part of the money arising from the sale of the whole.

Hence it will be seen that the land-owner risks nothing but a little injury to the surface of his fields, which will appear trifling when it is considered that if the mine is unsuccessful, the work is soon stopped; and that on the other hand many cases exist, where, by the sacrifice of an acre or two of land, an income of two or three thousand pounds has been obtained for several years.

The mode of levying the dues on the gross produce of a mine, tends to discourage enterprize, where considerable expense is incurred by the adventurers without an immediate return. It seems reasonable that the land-owners should contribute something in favor of that exertion which so often leads to their great advantage.

If an equitable mode of assessing the dues in some proportion to the net profit, could be devised, and was liberally and fairly acted upon, it would probably tend more than any thing else to the encouragement of mining.

As it now stands, the land-owner often derives a great revenue from a mine, which is swallowing up the money of the adventurers.

2. *The Arrangements between the Partners or Adventurers themselves, and the System of Controul and Management appointed by them.*

The parties who take the set, after reserving such shares in the adventure for themselves as they are disposed to carry on, generally allot the remainder to such of their friends as are inclined to join them. The whole concern is usually divided into 64 shares or doles, which division admits of its being held in various proportions, so that one person may have an eighth of the mine, another a sixteenth, and so on, until the whole is taken up.

The disbursements or *costs* are added up at the end of certain periods, seldom exceeding three months, but more generally at the end of every two months, at which times the adventurers meet and examine the accounts; each contributes his quota of money in time for the pay-day, which takes place regularly soon after.

When the mine becomes productive, the accounts are closed at the same periods, and the profit divided to the adventurers in the same manner. A balance to answer the advances made to the men, and other contingencies, is usually left in the hands of the purser or principal agent.

The general detail of management is often delegated to one person, who controuls and superintends the whole affairs of the mine; most commonly this person is one of the parties concerned in the undertaking, and one who from having made the profession his regular pursuit, and having, as is often the case, the care of several mines, is well fitted for so important a task. Some mines have the conduct of their affairs more divided, by the financial part being entrusted to a *purser*, and the management of the works to the principal *captain* acting under the direction of the meetings of the adventurers.

The agents who attend regularly to the operations, and who govern the executive part, are called *captains*, and are practical miners, selected for their skill and character, and who frequently pass from situations of subordinate trust and importance to those of great responsibility. Their general character is well known to those who have had occasion to visit the mining districts now under consideration; and it would be unjust not to notice here, how much of the perfection of the system of management in the mines has been owing to the zeal and intelligence of this respectable class of men, and how much its useful application constantly depends on their knowledge and activity.

The captains take different departments of duty in such mines as are sufficiently extensive to require it. The principal or managing captain has the superintendance of the whole, and gives his attention to every thing that may demand it, either underground or on the surface.

Most of the other captains are employed in viewing and controling the operations of the miners, and are called *underground captains*; they regularly visit different parts of the mine for this purpose, by night as well as by day, relieving each other in turn. They assist the managing captain in valuing the various prices of work to be offered to the men, and enforce the due performance of the contracts made with them. Their opinion is most important on all questions relating to the operations to be pursued, whether for discovery or for the best means of working what is already discovered; and they possess generally so much knowledge of practical mechanics applicable to mining, as to be able to direct in all common cases what is necessary to be done in the erection or repair of much of the machinery employed.

A *grass captain* or *dresser* is appointed, who has charge of the processes going on at the surface, and who regulates every thing relating to the preparation of the ores for sale.

The captains are assisted in other departments by an engineer who often superintends the engines of several mines, and by clerks to keep the accounts. They have likewise under them a *pitman*, who looks after the pumpwork in the shafts, and the underground machinery in general, a *timberman* or *binder*, who takes care that the ground is properly secured by supports of wood, and that the casings and ladders in the shafts are well put in, and kept in good repair.

The establishment of a mine likewise includes often a *material* *man* who looks to the receipt and due delivery of articles used in working the mine, and a principal carpenter and blacksmith, though the two latter are often employed by contract.

3. *The Mode of employing and paying the Miners and Workmen in Use among the Agents of the principal Mines.*

We now come to that part of the economy of the Cornish mines, which is most deserving of consideration from the effects it has produced, not only by procuring regularly a great deal of effective labour in proportion to the money paid for it, but also by turning that labour into such a direction as to make it the interest of the workmen to increase the discoveries of ore, and to work it and make it saleable in the most economical manner. Thus the owners of the mine have the advantage of all the intellect and skill that the men collectively possess, and have only to guard against the chances of fraud which such a system may be supposed to be subject to, but which are in fact under intelligent and faithful agents of too trifling a nature to be accounted of any importance.

The work of the mines, on the surface as well as underground, is universally performed by contract, and in this particular the practice of this district is probably similar to that of other mining establishments in different parts of the kingdom. Day work is in general disrepute in the stannaries, and is seldom resorted to, but where jobs are to be performed which either hardly admit of a previous estimate, or are too trifling to be worth contracting for; so that the charges under this head, among all the various operations of a large and well-managed mine, usually amount to but a very small proportion of the whole.

The plan of making the contracts with the miners, which it is believed is peculiar to Cornwall and Devon, and which holds a distinguished place in the economy of the mines, is that of periodically bringing all the work to a kind of public auction. Thus such a degree of competition among the workmen is constantly excited as to cause the price of labour always to bear on the whole, a fair proportion to the demand, combined with the considerations connected with the varying expenses of living. Thus superior skill and industry have their due advantage; and thus are the adventurers even guarded in some degree against want of skill in their captains, whose judgment is always corrected by the results of the *setting*. The only danger to be apprehended is from a combination of the men; but this is effectually prevented by the captains reserving the power of offering the bargain upon their own terms after the men have ceased to bid, if no one is found to go as low as they deem proper, or to withdraw the bargain altogether.

The act of contracting with the workmen is called a *setting*, and this in general takes place at the end of every two months, the auction is denominated a *survey*, and is held in the open air before the counting-house of the mine, which is generally provided with an elevated stage for the captains to stand on.

Three descriptions of contracts are put up at the surveys, according to the kind of labour to be performed, which is comprehended under the denominations of *tutwork*, *tribute*, and *dressing*.

Tutwork includes work done by measure, such as sinking shafts, driving levels, or stoaping ground; the first being paid for by the fathom in depth, the second by the fathom in length, and the third by the cubic or solid fathom.

Tribute is payment for raising or dressing ore by a certain part of its real value when merchantable, and it is this part of the system that is deserving of most attention, both on account of the excitement it produces to discover ore and to raise it cheaply, as already noticed, and on account of the perfect state to which the arrangements with the working miners under this head have been brought.

Dressing contracted for at the surveys is seldom for more than the waste or leavings of the tributors, the ores raised on tribute being made merchantable under the same contract; but as the men working on the terms usually made, cannot often afford to dress the coarser parts of what they raise, they reject it, and it is let to others who stamp and clean it, having a proportional price likewise in the way of tribute.

The tutwork is divided into lots, called *bargains;* each bargain requiring a certain set of men, and the gang so employed is always called a *pair* of men, let the number be what it may. Shafts have from 4 to 12 men, levels from 2 to 6 men in a *pair:* one usually agrees for the whole, and he is called the *taker*.

The tribute is set in *pitches*, each including a certain defined space of ground, limited very accurately, and each pitch employs from 2 to 6 men.

Dressing is set in bargains, and generally each to one man who employs the women and boys who assist him.

The day or two before the setting is occupied by the captains in measuring all the work done on tutwork in the shafts, levels, &c. and in carefully viewing the tribute pitches, so as to estimate nearly what each ought to set at. From these observations an accurate list and statement is made out, which the managing captain refers to in conducting the setting.

About the middle of the day the men are summoned and assemble in considerable numbers, as not only those who worked in the mine the former two months, but all such as are in want of employ attend on these occasions, which indeed is the cause of the competition so often observed.

The business begins by reading over what is called a *general article*, or set of rules and conditions subject to which every contract is made, and which article prescribes fines for fraud or neglect in the performance of the work.

When this is read the managing captain generally begins with the tutwork, and puts up a shaft or level, declaring the number of men required, and sometimes limiting the extent of the bargain to a certain depth or length. The men who worked it last usually put it up, asking frequently double what they mean to take; this they do, not so much in the expectation that it will influence the agents, as with the view of deterring other men from opposing them. Offers are then made at lower prices, which go on until no one is inclined to bid less, when the captain throws up a small stone, and declares who is the last offerer. It seldom happens that the price bid is so low as the agents deem equivalent, therefore it is understood that the last man is only entitled to the option of closing the contract upon the terms to be named by the captain; these are therefore immediately proposed, and if refused, are tendered to the others in the order of their offers.

This plan reserves the power to the agents of withholding, in case of combination, while the men, though they may not in the first instance bid down to the price they mean to work for, seldom risk a refusal when the captain's offer is made, if they think it near the mark, least others should instantly accept it.

The tribute pitches are set in the same way, the place intended to be worked being described, with a stated number of men, and the offer being made at so much in the pound, that is, a certain sum out of every twenty shillings worth of ore raised and sold. The tribute may vary from threepence in the pound to fourteen or fifteen shillings.

The Tutwork men divide their *pairs* into lesser gangs, called *corps* or *cores*,* each corps consisting of two or three men; they work alternately, relieving each other throughout the twenty-four hours. Thus a pair of six men will divide into three corps, each working eight hours a day.

An account is opened at the counting-house with the taker or principal man of the pair, wherein he is debited with the value of all tools delivered to him by the smith, and the expences of sharpening and repairing them during the *taking*, or term of the contract, also, with the candles, gunpowder, and other articles used by him and his partners, with the charges on hauling up the waste to the surface, and likewise with cash advanced, called *subsist*. After the taking is out, the account is credited with the amount arising from the measurement of the ground at the agreed price, and with the tools and other articles returned unemployed. The pay-day is generally about a fortnight after the taking ends, when the balances are paid.

Tribute pitches require much more calculation in estimating the price at which they can be worked, and a more complicated set of accounts during their progress.

The proportion of the value of the ore to be allowed the workmen, must depend on the amount they can procure in a given time and at a given expense. Therefore the size and productiveness of the lode, the hardness of the ground, the quality of the ore, and the cost of hauling to the surface, as well as dressing it for sale, and the market price of the metal, are important elements in the calculation.

To the habit of investigation induced by this plan of payment may probably be attributed a great deal of the intelligence observable among the Cornish tributers, and to the desire of making

* See Pryce.

the most of their talents by looking after pitches, which though unproductive in present appearance, may improve in working, is owing a great proportion of the lesser discoveries constantly made, and which contribute in no small degree to the profit of the adventurers.

The tribute work of Cornwall may be thought to be similar to what is done in many other mines, as in Derbyshire, where the men raise the ore at what is called a *cape*, or at a certain sum for every ton of ore they may produce. But it will appear that though this approaches to the Cornish plan, yet that it falls very short of it.

The payment in Cornwall being in exact proportion to the selling value of the ores, which is there settled very accurately according to the metal contained in them, not only instigates the miner to dicover and produce as much as he can, but leads him to consider every circumstance which may diminish the expence of returning it, or may enable him to produce the greatest quantity of each metal at the lowest charge of dressing as well as raising.

The tributor's account is charged with tools, materials, and money, in the same way as that of the tutwork men, and they are likewise debited with the wages of the persons employed to dress their ores. The credit side of their account is not closed until the ore is actually sold and weighed off to the smelting companies who may purchase from the mine, as the value of every tributor's parcel is compared with the aggregate assay and sale, before they are settled with, and the differences, if any, divided among the whole, by an increase or drawback on each.

In the copper mines, when a tributor's parcel of ore is ready, it is weighed off by one of the captains, and turned over to the general heap, or as it is called, the *public parcel*, at the same time samples are very accurately taken and sealed up. One of these samples is delivered to an assay master for the mine, another the miner takes to have it assayed if he chooses, and a third is reserved for re-trial in case of dispute. After the market-price of copper has been determined by the result of the sale which governs the settling, the price of each parcel is made up according to the assay, and from the amount of the whole the tribute is carried to the credit of the taker, and the balance settled at the following pay-day.

The rate of earnings in tribute is extremely uncertain, and the employment is consequently speculative in a great degree. If a set of men working on a poor part of the lode where they may have agreed for seven or eight shillings in the pound, discover a bunch of ore rich enough to set at two or three shillings, they earn money very rapidly, and instances have often occurred where a set of miners have divided more than one hundred pounds a man for two months work. On the other hand, when the lode fails, and becomes poor, being obliged to go on with the contract, the men may at the end have their account in debt, not having even enough to pay for the articles they consume.

The cases of extraordinary earnings probably benefit the owners of the mine much more than those in which the men are indifferently paid. They are not likely to happen often, and when they do, they are attendant on some discovery favourable in the first instance to the men, but eventually much more so to the owners. They produce great energy and activity not only in those who benefit from them, but animate all the others, who increase their exertion in hopes of some similar discovery; they encourage competition, and frequently bring neglected parts of the mine into effective and profitable working.

Dressing the ores by tribute tends to produce accurate calculation as to the amount of labour which can be afforded to all the different varieties, and it has become therefore the common practice to regulate these processes by a constant reference to the assay, which prevents a waste of metal on the one hand, or a useless expence on the other.

4. *The purchase of the Materials employed for carrying on the undertaking.*

This part of the economy of the mines of Cornwall has been censured, inasmuch as the concerns are often supplied by a part of the adventurers who are dealers in the articles required, and who therefore have a concurring interest in allowing exorbitant prices and an unlimited consumption.

Where the majority of the property of a mine is in the hands of those who look to their contracts for the supply of materials as a source of profit, no check can well be devised to guard the interest of the other adventurers, and it might become a question with any person about to engage in a mine under such circumstances. But where the mercantile part of the adventurers hold a smaller part of the property, contracts of this sort, and the appointment of agents being under the controul of the majority, they may easily take measures to secure the purchase of all articles at a fair price, without depriving their fellow adventurers of that preference which their interest in the mine fairly entitles them to.

5. *The Sale of the Ores from the Mine Adventurers to the Smelting Companies.*

Tin ores are smelted in Cornwall at smelting-houses belonging to different persons who are likewise generally adventurers in tin mines.

Copper ores are mostly smelted in South Wales, near Swansea, being carried there on account of the great quantity of coal required. There is however one copper smelting establishment on the northern coast of Cornwall.

The sale of tin ores is not very well conducted, as the miner is obliged to carry them to the smelting-house where they are assayed, and the parties make the best bargain they can.

The smelting copper ores is a much more difficult operation than that of tin, and requires a very expensive establishment and the investment of an immense capital.

There are about 15 copper companies, and they have all agents and assay officers in Cornwall; there is a weekly meeting at some place near the great mines, called a ticketing, where all the agents of the copper companies attend. At these ticketings the ores of different mines allotted in suitable parcels are offered for sale.

Due notice having been given of the ores intended to be sold on a particular day, an agent of the smelting companies attends at the mine some time before the day of sale to take samples of the different parcels. The ores are prepared for this purpose by being placed in regular heaps called *doles*, each lot of ore being equally and carefully divided into six doles. One of them is fixed on by the buyers' agent, which after being well turned over and accurately mixed, is rounded into a regular form, and then a trench is cut through the middle, from the sides of which the sampler scrapes uniformly a certain quantity. A portion of this is then taken, bruised and sifted, and from it a sufficient number of samples are packed up in bags, which are carefully sealed and sent to the assay masters of all the copper companies.

The buyers are thus furnished with the exact produce of fine copper in each parcel which will be submitted for sale at the ticketing, and by calculating the market price of the metal and the smelting charges they govern their affairs.

The meeting is attended by the agents and adventurers of the mines as well as by the agents of the copper companies, and one of the former usually presides. The offers for each parcel of ore are made by the buyers' agents handing to the chairman a note or ticket containing a fixed price per ton, he opens and reads out the whole, when the highest offer is at once declared the purchaser.

The ores remain on the mine for a given time, when an agent of the copper company attends to weigh them, and they are afterwards conveyed to the coast for shipping to Wales.

Copper ores do not bear a price exactly proportioned to the quantity of metal they contain, some ores being more intractable in the fire than others or yielding copper of an inferior quality.

From repeated experiment the smelting companies know the effect that the mixture of particular ores has in the furnace upon each other, depending on the nature of the mineralizing substance or the kind of matrix which enters into the mass. On this account they regulate their offers by the quality of the stock they have on hand, or they manage so as to purchase ores from mines which may best suit to mix with others which they have previously bought. Thus it is well known that the produce of some mines does not bring the price that its proportion of metal would entitle it to, while that of others, more esteemed by the smelters, always bears a higher relative value.

It remains to say a few words on the subject of mines considered as property, particularly as shares in these undertakings are now frequently bought and sold at a distance from the districts in which they are situate, and as their value is not often appreciated according to correct data.

From what was said of the arrangements between the parties who undertake a mine by a joint adventure, it may be concluded that a share in a new concern costs no more to the original holders than the proportion of the expences actually incurred. As the mine proceeds, every adventurer may value his share according to his own opinion of the prospect of success, and therefore considerable diversity in this respect may arise. In some concerns the value of shares may rapidly improve by the discovery of ore or favourable symptoms, and be soon estimated at much more than the amount of cost paid; in others, the chance of success may be constantly lessening, and a reduction in the value of shares will be proportional.

The value of property even in mines that are established and productive, cannot be determined by any definite rule. They are liable to great and important changes, leading from great gains sometimes even to considerable loss, and on the other hand emerging from a state of nearly balanced cost and return to that of great and rapid profit.

The rate of gain for any given time forms no true criterion by which to judge of the value of mines, though it is the one by which most who purchase or sell without sufficient experience are usually guided. A concern still profitable to a considerable degree, may have all the symptoms of speedy decay, while on the other hand mines which are producing but little, or are even yet burdensome to their proprietors, may be those in which the greatest chance of ultimate success is probable.

Mining has often got into great disrepute as a mode of employing money, from a want of due consideration of all these circumstances in the persons who have engaged their property in this way; artful men may have aided the delusion in many instances, and in many others a pertinacious adherence to adventures of but little hope may have aggravated the disappointment.

On the whole probably mining does not yield any great profit to the adventurers, but there are numerous cases of extraordinary gain, and these are probably nearly balanced by more numerous concerns in which loss is incurred, the latter however, if taken individually, being generally much less in amount than the former.

From this it will follow that the chances of success are against any single mine at its first undertaking, and on the whole in favour of a greater number, when conducted with skill and honor.

XV. *On the Origin of a remarkable class of Organic Impressions occurring in Nodules of Flint.*

By the Rev. William Conybeare, of Christ Church, Oxford, M.G.S.

THE suite of specimens accompanying the following notice are submitted to the inspection of the Geological Society, as illustrating the history of certain organic impressions which are found occurring in the flinty nodules of the chalk strata, and of which the real origin had previously escaped detection.

Mr. Parkinson, is I believe, the first naturalist who has noticed similar specimens; the following description of them is given in the second vol. of his valuable work on organic remains, and it is not possible to convey a more accurate idea of their external characters.

" Small round compressed bodies not exceeding the eighth of an inch in their longest diameters, and horizontally disposed, are connected by processes nearly of the fineness of a hair which pass from different parts of each of these bodies, and are attached to the surrounding ones; the whole of these bodies being thus held in connection." Page 75, 76.

Mr. Parkinson proceeds to conjecture " that the formation of these bodies has been the work of some animal of a nature similar to the polypes by which the known Zoophytes are formed." He therefore classes them among fossil corals of unknown genera, acknowledging at the same time that the circumstances which induced him thus to arrange them were very slight, and that they differed essentially from every zoophyte, recent or fossil, with which he was acquainted.

The impressions in question are generally found in a state of such indifferent preservation, and afford such insufficient data on which any conjectures concerning their formation can be founded, that we shall not be surprised to find the more perfect specimens now submitted to the Society, decidedly militating against the hypothesis proposed by the able fossilist above cited, and proving that the real origin of these bodies is widely different from that which he has assigned, they being in fact siliceous casts moulded in little hollow cells excavated in the substance of certain marine shells; the work perhaps of animalcules preying on those shells and on the vermes inhabiting them. It is almost unnecessary to add that these casts, like the screw stones of Derbyshire, must have been formed by the infiltration of the siliceous matter while yet in a fluid state into the cavities of the shells which it enveloped, and that they have been laid open and denuded in the specimens at present under consideration, by subsequent exposure to some agent capable of dissolving and removing the calcareous matter of the shell which formed the matrix, while the siliceous impression resisted it and remained unaltered.

My first suspicion of these facts arose from a minute examination of the specimen represented in the drawings by fig. 1, Pl. 14. It presented several appearances which seemed to indicate the following conclusions.

1. That the flat surface of flint over which the globules are in that specimen distributed, had been originally occupied by a large piece of the striated shell, the fragments of which occur so abundantly in the chalk-strata and accompanying flints, being very commonly considered as mutilated portions of a fossil pinna.

2. That the globules themselves were casts moulded (in the manner already described) in cavities existing in the substance of the shell in question.

The most important of the appearances from whence these conclusions seemed to be deducible were the following.

The flat surface occupied by the globular bodies at one extremity of fig. 2. is terminated by the perpendicular face or escarpment (if I may so employ that term) formed by a portion of the flint elevated a little above the rest; and this escarpment will be found marked with minute vertical striæ, seeming to indicate that it had been moulded against the edge of a fragment of the striated shell already alluded to; similar striæ are observable round the edges of another elevated portion towards the centre of the specimen, in some degree resembling the mill-marks round the edge of a coin, and they again occur on both sides of a small vein, or rather dyke of flint traversing a cluster of globules, and cutting many of them through the middle. This striated *dyke* had therefore all the characters of an impression formed in a long and narrow fissure of the shell in question, and was connected with the globular bodies in such a manner that the formation of the latter could scarcely be assigned to any other cause than that which produced the former.

In order to represent these appearances more clearly to the eye, several slight liberties have been taken in the drawing fig. 1. the relative position of some parts of the original specimen has been changed, and to the indications in question, a more prominent character than they really possess has been given. The small scale of the general outline fig. 1. not exceeding one of the original size, has rendered this more necessary; but in fig. 2. a detached representation of the siliceous dyke traversing the globular bodies has been added, on a scale rather larger than the original.

Desirous of pursuing the indications afforded by the circumstances above specified, I proceeded to examine many specimens of flint containing fragments of the striated shell in which the substance of the shell itself was still preserved, and in several instances observed evident traces of the siliceous globules of the cast, imbedded in their testaceous matrix; by submitting such specimens to the action of a diluted acid, that matrix was easily removed, and the casts themselves thus laid open by the destruction of their envelope, exhibited a perfect resemblance to the specimens previously described; the origin therefore which my former conjectures had induced me to attribute to those specimens now received the confirmation of a decisive experiment.

The two compartments of fig. 3, exhibit representations of a specimen of the kind last described, before and after its denudation by the action of the acid. The specimen itself from which the latter draught was made, is submitted to the Society, together with the remainder of the mass of flint from which it was broken in an unaltered state.

The succeeding figure (4.) exhibits, on a scale rather enlarged, a section carried vertically through a part of the specimen just described. The cellules forming the matrices of the globular casts will be seen in this section to have occupied nearly the whole thickness of the plate of shell. The numerous filaments extending between the globules in every direction, preserve the traces of as many minute tubes in which they must originally have been moulded, and it will be farther perceived that each globule is connected with the flinty envelope immediately above and below its centre by two thicker stems resembling the extremities of a projecting axis.

The next specimen of the suite (fig. 5.) is a large fragment of some nondescript shell of the same striated structure; on a part of its fractured margin a range of hollow cellules will be observed similar to those which in the earlier specimens have been occupied by the infiltration of silex. In the present instance the specimen has been imbedded in chalk only, and the removal of that soft substance has exposed the cellules in their empty state.

I have assigned the succeeding figure (6.) to a very interesting specimen, for the use of which I am indebted to Mr. Parkinson; it exhibits nearly the entire cast of a striated shell supposed by Mr. P. to be similar to that which Walch has described under the name of the Ostreo-Pinnite; the shell in which this cast was formed, must have become in places almost entirely cellular in its texture from numerous perforations of the kind so often alluded to, since the inferior margin of the upper valve is completely studded with a congeries of their globular casts of every size from that of the head of the smallest pin to discs of the eighth part of an inch in diameter.

Fig. 7. represents a very delicate groupe of minute globules, which requires the assistance of a magnifying lens before its analogy with the preceding specimens can be perceived. To the naked eye it rather assumes the appearance of a coralloid; a magnified delineation of the same groupe is added, it is copied from a part of a large white flint found at Heytesbury, in Wiltshire, over the surface of which many such groupes are scattered, accompanied with impressions of fragments of the striated shell described by Da Costa as a patellite (Elements of Conchology, p. 142.): it is the flatter variety of the two which he describes, and it resembles that figured by Mr. Parkinson. Organ. Rem. Vol. 3. Pl. 5. fig. 3.

In all the preceding instances, the shells in which the cellules have been originally formed, have belonged to one class of fossil shells, the class (namely) which is distinguished by a striated texture similar to that of the recent pinna marina.

Owing to the great brittleness resulting from this texture, the specimens of such shells hitherto obtained have been found in too mutilated a state to authorise any definitive opinion with regard to their systematic classification. We may however securely venture to pronounce from the data in our possession, that there must certainly have existed more than one species, and most probably more than one genus of shells in which this structure prevailed; some of the fragments found may perhaps have belonged to a fossil pinna, others appear rather to resemble parts of a shell of the genus ostrea. Da Costa's conjecture formerly cited, which refers them to the patella does not seem to be grounded on sufficient evidence.

Had the cellular excavations occurred only in shells of this class, concerning which our information is so imperfect, it might have been conjectured perhaps that they resulted from an original peculiarity in the organization of such shells, but the occurrence of an impression evidently moulded in similar cellules on the surface of a cast of the echinus has proved that this cannot be the case. The specimen alluded to is represented in fig. 9, the conjecture therefore originally proposed, namely that these cellules were the work of animalcules preying on the shells, and on the vermes inhabiting them seems to be the simplest manner of accounting for their formation.

I might perhaps cite the specimen represented in fig. 8, for the same purpose with that last referred to, as affording another example of a similar cast formed in a body distinct from the striated shell; in this specimen a beautiful groupe of globules is seen occupying a conical hollow sunk into the substance of a flint pebble, and apparently formed by the impression of the pointed end of a belemnite. It is fair however to state, that together with fragments of the striated shell, certain testaceous bodies of a tapering cylindrical figure (which have seemingly constituted processes attached to such shells) are not unfrequently found in the chalk strata, and that the last in question may possibly have been moulded in a fragment of this. The specimen itself is from the collection of Mr. Parkinson, to whose kind assistance during the course of these enquiries, I am happy to acknowledge myself much indebted.

I cannot conclude without apologizing to the Society for having occupied so much of its attention, by minute details which I fear may have appeared extremely jejune and uninteresting, as they are confined to the illustration of an insulated fact in the history of organic remains, in itself of very inferior importance, and cannot be said to throw any additional light on the general views even of that branch of geological science with which they are connected.

Since writing the above I have received from my friend Mr. Buckland the following observations relative to this subject, accompanied by a recent specimen which appears to illustrate them in a very satisfactory manner.

" The hollows that afforded a mould for the formation of these singular bodies, appear to me to have been the work of some minute parasitical insect. The small aperture, the cast of which now forms the projecting axis of each globule, was probably perforated by this intruder as the entrance to his future habitation ; having completed this passage, and excavated at its termination a cell suited to his shape and convenience, he appears by the aid of a delicate auger or proboscis to have drilled many minute and almost capillary perforations into the substance of the shell on every side around him, taking care to leave always partitions sufficient to support the thin external plate of shell which formed the roof of his apartment. Having exhausted all the nourishment which could in this manner be procured with safety from the vicinity of this first establishment, the insect appears to have emigrated, and after working for itself a lateral passage to a sufficient distance, to have formed a new settlement in the midst of fresh supplies. In the recent oyster shell which I have transmitted, you will perceive that this process has been carried on to a great extent, in the intermedial matter between two or three sets of the pearly plates comprising it; and yet without effecting the destruction of the exterior crust, or in any degree injuring the inner surface of the shell, which remains untouched, and, notwithstanding these attacks, still equally adapted to every purpose required by the œconomy of its inhabitant.

XVI. *A Description of the Oxyd of Tin, the production of Cornwall; of the Primitive Crystal and its modifications, including an attempt to ascertain with precision, the admeasurement of the angles, by means of the reflecting Goniometer of Dr. Wollaston: to which is added, a series of its crystalline forms and varieties.*

By Mr. William Phillips, Member of the Geological Society.

THE oxyd of Tin, Étain oxydé of the French, Zinnstein of the Germans, has for many centuries given to Cornwall an important place in the economical history of nations. It is asserted by Pliny* that the Phœnicians visited its coasts, and carried on a lucrative commerce in tin with its inhabitants.

Cornwall is justly celebrated not only for its inexhaustible stores of this valuable substance, but for the superior quality of the substance itself; for, according to Klaproth, it is purer than that of Bohemia and Saxony, as it contains both less iron and less arsenic: and although the oxyd of tin is or has been found in almost every district of Cornwall, it is nevertheless one of those substances which are the least abundantly dispersed throughout the globe.† Many considerable countries are entirely without it; but it is found in Gallicia in Spain, in Bohemia, in Saxony, in Banca and Malacca in the East Indies, and in Chili in South America.

* Lib. iv. cap. 34. † Brongniart, p. 192.

Brongniart says,* that "tin belongs exclusively to primitive countries, and even to those of the oldest formation; for not only is it found in veins and beds in granite, but also in masses, or disseminated in beds of gneiss, of micaceous shistus, and of porphyry. Veins of tin adhere very often to the walls of the lode, by the rock which encloses them; they are always divided by other veins, and never divide them. Tin therefore seems to be one of the metals of the oldest formation: it is accompanied by substances which belong to the same age, such as wolfram, arsenicated iron, topaz, quartz, fluated lime, phosphated lime, hornblende, green and black mica, chlorite, &c. whilst carbonated lime, sulphated barytes, zinc, lead and silver, substances which frequently accompany other metals, are *rarely* found with it." All this may perhaps be true, in so far as it regards depositions of tin in other countries, but I am induced to believe it is not wholly so in regard to Cornwall, where veins producing tin often occur in districts, both granitic and schistose, which it seems difficult to ascribe to the primitive formation.

Dr. Berger† in his paper on the physical structure of Devonshire and Cornwall, says, "Here (Cornwall), as in the Hartz, it (grauwacke) is very rich in ore." In the term grauwacke, Dr. Berger, following the example of Werner, seems to include every species of that rock, usually called schist, and by the miner killas. He further says‡, "Grauwacke is one of the oldest of the *secondary* rocks." Again, § in speaking of the discovery of uranium in Tin Croft mine, which is situated at the foot of a granitic hill, but partly in granite and partly in schist, its "being found in this district proves that, contrary to the opinion of Werner, it may be met with in *secondary* mountains."

* Traité Elem. p. 191. † Geolog. Trans. vol. 1. p. 113.
‡ p. 111. § p. 170.

The above quotations from Dr. Berger's valuable paper are given solely with a view of shewing it to be his opinion that at least one district of Cornwall, producing tin, is not primitive. This has long been my opinion of that district, as well as of other parts of that county in which tin is found: and I cannot doubt but some specimens of granite in my collection from different places, enclosing tin, tend to confirm that opinion. But it may be well to await the developement of many facts, which yet remain requisite to the better understanding of the geology of the county, as well as the light that might be thrown on the subject by a more perfect agreement in the use of geological language.

The existence of tin in the native or pure state is no longer believed. It was admitted by Romé de Lisle to have been so found, from the examination of a specimen from Cornwall under that name, which, by the description he has given of it, seemed to partake of the exterior appearance of molybdena. I possess a specimen of tin, found in the neighbourhood of St. Austle in that county, which with two or three others was arranged in the collection of my late uncle, now in my possession, under the name of native tin. It is almost coated by a ferruginous rust, and on one of its larger sides there are numerous portions of a very hard substance resembling iron, in which are embedded minute pieces of quartz; on this side I presume it to have been deposited. The fracture in some places is that of the finest steel-grained sulphuret of lead. The more pure parts of it easily flatten under the hammer, and fall off in small scales, which crackle between the teeth and easily yield to the knife. This specimen seems very much to agree with some found in France by Schreiber, an account of which he has given in the Journal des Mines, except that those were accompanied by a white substance, which proved to be the white muriate of tin.

Those specimens which heretofore were called native tin, are now generally believed to have been accidentally left by the smelters of the ore, and wherever it is discovered, the place may fairly be supposed to be the site of a smelting-place. It has now obtained the name of Jews-house tin.

The oxyd of tin is rarely found in Cornwall free from an admixture with other substances, but in this state it has been produced in masses of considerable size. From the mine called* Polberrow in St. Agness, one block of tin ore was raised weighing 1200lbs. which produced more than one half of metal. The oxyd of tin seems to occur almost uniformly in a state of crystallization, with whatever substances it is intermingled, or however minute its portions, in the common tin-stone of the mines. It is rarely found in shapeless masses, except, indeed, the rounded grains of alluvial deposition; and even amongst these many appearances of crystallization, but mostly of the macle, may be noticed. Not only are the same crystalline forms generally apparent on each cabinet specimen, but even entire veins seem to be productive principally of the same varieties. In the tin-stone of Polgooth near St. Austle, I have rarely seen any other than minute crystals of the form of fig. 66, Pl. 18. That produced by Pednandrae, an extensive tin mine close by the town of Redruth, is almost uniformly of the macle described by fig. 208. Pl. 25. From Huel Fanny mine, which produced tin only in the shallow part of the copper vein, I have never observed any other forms than those described by figs. 108. Pl. 20. and 160. and 162. Pl. 22. and many of the crystals figured in the series of the 7th and 9th modifications, have, I believe, only been brought from Relistian mine. If it should hereafter more generally appear

* Pryce, Min. Corn. p. 68.

that some modifications of the primitive crystal of this substance are principally the production of particular districts, as I am led to suspect will be the case, might not an investigation of the nature and peculiarities of the veins, and of the country through which they pass, tend to throw some light on the circumstances, or laws, by which the several modifications are produced: may not these circumstances be supposed in some degree to depend on the purity of the substance itself, or to be affected by the various proportions of other substances entering into combination with it? The Bohemian oxyd has not hitherto been observed to assume so great a diversity of crystalline forms as the Cornish, which by the analysis of Klaproth already noticed, appears to be by far the most pure.

The crystals of this substance from Bohemia are generally much larger than those from Cornwall, but Pryce mentions one he had seen that weighed upwards of two ounces. Very large crystals, mostly of the macle, I believe, were found in Seal-hole and Trevonance mines in St. Agness; in the former they were lying loose in the vein, and were conveyed without first breaking or purifying them, immediately from the mine to the smelting-house. Some have also lately been brought from a mine in the neighbourhood of the Tamar, and others from near the Land's End; but instances of this kind are by no means common. The crystals of this substance are generally in part imbedded in the matrix; they are not commonly so disposed as to shew both paramids, and are sometimes confusedly grouped, but this appearance of confusion principally arises from a circumstance which will be hereafter explained in speaking of the macle, to which the oxyd of tin is so liable. The crystals are rarely disposed in radii, but I have one specimen on which they are so disposed. Radiated schorl has often been mistaken for tin, to which it frequently bears considerable resmblance.

The oxyd of tin sometimes occurs in form and appearance very similar to the hematitic iron ore, from which it is easily distinguished by its superior weight. In this state it is mostly in fragments, either straight or diverging, wedge shaped or splintery, rarely rounded and reniform; those fragments of which the fracture is fibrous, have a silky lustre; its colour is brown of different shades, passing into brownish-yellow, which are ranged in alternate bands; it gives a shining yellowish-brown streak, and is opaque, hard, brittle, and easily frangible; its spec. grav. is 6.45. This mineral from its occasional resemblance to wood, has obtained the name of wood tin, and is the Kornisches zinnerz of Werner, the Etain oxydé concretionné of Haüy. Before the blowpipe it becomes brownish-red and decrepitates, but is not fused or reduced to a metallic state: when strongly heated in a charcoal crucible, it affords, according to Klaproth, 73 per cent. of reguline tin. It has hitherto been found only in Cornwall, in the parishes of St. Columb, St. Roach and St. Dennis, in alluvial beds accompanied by stream tin; it is rare, and occurs only in small pieces.*

Klaproth mentions "a kind of wood tin, from Maddern in Cornwall. This is only found in small separate hemispheres, of the size of a divided shot. The surface is smooth and brown, but the inside or nucleus is of a light brown and of a whitish-yellow colour, and slightly radiated. These stalactitical hemispheres, which, as one may see, have been fixed to other bodies, are similar to the small spherical protuberances of wood tin, except that the latter are not so hemispherical, but flatter."† This substance, I do not remember to have seen in the form above described, but some rounded portions of tin were given to me by a Cornish gentleman

* Aikin Chim. Dict. art. Tin.

† Klaproth on Fossils of Cornwall, p. 21.

some years ago, under the name of pea tin, perhaps from their size. They have evidently been rounded by attrition, and appear to be a species of wood tin from the variation in colour on the surface, which is generally of a hair-brown.

There is in my collection, a specimen, which I took from the heaps of tin on Poldice mine, that is of remarkable character. The general mass is of a light brown colour; minute veins of different shades of brown and black tin alternate in bands in the same direction. It is compact and hard, but not brittle, and gives sparks with a steel; its fracture is uneven. It may be well supposed from its great weight, to consist almost wholly of the oxyd of tin. It is accompanied by the black oxyd on one side, and very minute veins, apparently of quartz, traverse it in various directions.

Alluvial depositions of tin of considerable extent and depth have been found in several parts of Cornwall, which it is believed, is the only part of Europe in which tin occurs under these circumstances. The grains of it, which it may be presumed, are for the most part crystals rounded by attrition, are mostly very small, and sometimes exhibit marks of crystallization, generally of the macle. Stream tin affords from 65 to 75 per cent. of the purest grain tin. Its freedom from arsenic perhaps arises from the ore collected in the stream works being detached portions of the pure oxyd. And its presence in the regulus of tin procured from the ore of the veins may be supposed to arise from its being frequently accompanied by arsenicated iron. It is somewhat remarkable that the only traces of gold to be found in Cornwall, are in the stream works, in which it sometimes occurs in small grains, mostly detached, but occasionally accompanied by quartz. A few years ago, a specimen of considerable size was discovered, I believe in Carnan stream work, containing it is said the value of ten or eleven guineas in weight of gold. It is in the collection formerly belonging to the late Philip Rashleigh, Esq. of Menabilly.

Tin is not found mineralized by any other metal, and rarely in intimate combination with any other, except with copper in that mineral which is known by the name of sulphuret of tin. This substance has also obtained the names of bell-metal ore and pyritous tin. It is the Zinnkies of the Germans, the Etain pyriteux of the French, and has hitherto only been discovered in a mine called Huel Rock in the parish of St. Agness, in mass, never crystallized.* According to Klaproth, it contains tin 34, sulphur 25, copper 36, iron 2. Its colour is steel-grey, passing into bronze-yellow, in some parts inclining to silvery. Its fracture is unequal and granular. According to Klaproth, its specific gravity is 4.350; under the blowpipe it emits a sulphureous odour, and passes into a blackish slag: it gives a yellow tinge to glass of borax. Its lustre is metallic. It is brittle and easily frangible.

Among the specimens of oxyd of tin in my collection, it may be observed occurring

In Granite—in minute crystals interspersed through granite, from the south-west side of St. Michael's Mount—in granite, with chlorite and schorl from the south side of Redruth Church-town—with schorl in granite from near St. Just. In decomposing granite from Polgooth mine.

* Kirwan has described this mineral as "Tin mineralized by sulphur and associated with copper." On this definition Haüy has the following remark. "It may be proved by other examples, that this celebrated chemist is of opinion, which appears to me to be well founded, that a principle that presides in regard to quantity, may be only an accessary. Mineralogy will have made a great stride towards perfection, when this distinction between essential principles and those which are only accidental, shall be correctly applied to all minerals to which it strictly appertains."

In Schist—both micaceous, and of other descriptions from St. Agness—in small veins passing in various directions through light-coloured schist from St. Agness—crystallized, on rounded masses of aggregated fragments of schist (grauwacke) from Relistian mine.

In Chlorite—from Polgooth mine—in compact chlorite with imbedded crystals of mispickel from Relistian mine—on crystallized chlorite from Huel Unity.

In Schorl—from Huel Unity, and some mines in St. Just.

In Carbonate of Lime—very compact and semi-transparent, from Polgooth—with rhomboidal crystals of carbonate of lime from the same place—and with schiefer spar, also from Polgooth.

In Topaz—with quartz and topazes of a light yellow; on topaz in mass, as I suspect, in which are imbeded crystals of tin and quartz—with topazes of a greenish cast, imbedded in mica on decomposing granite—with topazes and chlorite, on granite—with white topazes, crystallized phosphate of lime, and silvery mica on granite, from St. Michael's Mount. Fom what districts the other specimens were brought is unknown, but they are from Cornwall.

In Calcedony—covered by white decomposing calcedony and by blue calcedony; both from Pendnandrae mine.

In Fluat of Lime—disseminated through brownish fluor, intimately mixed with chlorite from Pendnandrae—disseminated through a mass of white fluor, transparent and opake, and very fusible, from Huel Unity—with fluor, purple on the surface, quartz and chlorite on schist, from St. Agnes—imbedded in *Chlorophane,

* The mine called Pednandrae is, I believe, the only one in this country, in which chlorophane has been found. I obtained this specimen from it in 1805, which together with another, also in my possession, in which the chlorophane is almost completely imbedded in semi-transparent calcedony, is the only specimen that has been noticed. It is

accompanied by calcedony from Pednandrae. In searching the heaps of that mine for the chlorophane, I found several varieties of remarkably compact fluor *—also enclosing crystals of oxyd of tin, or accompanied by them.

In Yellow Copper Ore—imbedded with it—coated with yellow copper ore, and accompanied by chlorite—with yellow copper ore on micaceous schistus—with yellow copper ore, quartz, and chlorite, from Huel Fanny.

With Blende on quartz, from St. Agness.

In Mispickel—with mispickel on schist.

In Wolfram—with wolfram and dark brown gossan—with wolfram and chlor ite from Pednandrae mine—with the primitive crysta of wolfram, mispickel and yellow copper ore, from Huel Fanny.

The science of mineralogy is so intimately connected with some branches of the mathematics, that he who pretends to the former, unassisted by a knowledge of the latter, may perhaps be considered as pursuing it rather as an amusement, than as an object of scientific research. I confess myself to be exactly so circumstanced. The want of an attachment to the study of the mathematics, led me to

traversed in various directions by minute veins of chlorite, occasionally imbedding yellow copper ore and oxyd of tin. It is hard; scratches glass easily; its fracture is shattery and splintery. Its general colour is purplish; it is transparent at the edges, and the fragments are very transparent; a thin piece held for a short time in the flame of a candle, emits a brilliant green light, which becomes very brilliant by placing it on a live coal, from which, if it be taken at about the height of its light, it may be repeated, though with diminished effect; by frequent repetition it becomes nearly colourless. It does not fly even in the centre of a common fire.

* Some of these fluors deserve particular notice on account of their exhibiting some peculiar characteristic differences when compared with common fluor. One large specimen is of a bluish colour, and is traversed in various directions by veins of what I

neglect them in early life, which I have now occasion to regret, not only as it forbids the pursuit of mineralogy to an extent which alone would have enabled me to illustrate its objects in a manner wholly pleasing and satisfactory, but also as it renders me incompetent to reap the pleasure and instruction, which the works of those celebrated men the Abbé Haüy and the Count de Bournon, are calculated to convey. It must of course follow, that the only evidence I can offer in regard to the admeasurement and value of the angles of crystals, must be wholly mechanical.

I have given much attention in the endeavour to ascertain precisely the value of the angles of this substance, by the help of that admirable instrument the reflecting goniometer of Dr. Wollaston, having been previously assisted in its use by some hints and per-

conceive to be calcedony of a still lighter blue, though where most free from those veins, the general colour and appearance considerably resembles the chlorophane already described. It seems to have formed the principal part of a vein, being accompanied on each side by decomposing fluor, which has an ochreous crust similar to the gossan of the mines. On being placed on a live coal it gives a green light, nearly as splendid as the chlorophane, and does not fly; but flies when placed in the fire. It scratches glass easily.

Another kind of fluor also encloses tin, which is of a light but dull brown colour, and greasy lustre, and is somewhat transparent at the edges. Its fracture is shattery. It gives nearly the same light as the chlorophane, but flies in the fire, though not when placed on a live coal. One specimen, about an inch in thickness, has on one side, a smaller vein of fluor, enclosed between two minute veins of chlorite, and on the other side, compact white fluor; attached to each side, is a blue schist, the country of the mine. From the numerous crystals of tin imbedded in some specimens, I am induced to believe that it ran beside tin in the vein.

I found also several other singular varieties of fluor, much harder and more compact than fluor generally is, of which the fracture is shattery and the colour purplish. When placed on a live coal, some of them begin by giving a greenish light, which soon changes to purplish, and afterwards ends in a dark purple. Others, give only a purplish light, and these do not fly even in the fire. Others give only a light green when placed on a coal, without flying, but fly when placed in the fire.

sonal instructions from the ingenious and scientific inventor. Before I had arrived at some tolerable knowledge in its use, so as to be assured that the smaller crystals only can be relied on, the great differences which I found to exist in the same angles of the larger crystals, even though their planes appeared by the assistance of the magnifying glass, to be undeviating and polished surfaces, almost tempted me to doubt the utility of the instrument itself. These differences amounted in many instances to as much as 15', frequently 10'; while on the other hand, small crystals, having clear and perfect reflections, gave a coincidence in the admeasurement of the same angle.*

I feel therefore warranted in the conclusion that, although occa-

* The reflecting goniometer is so delicate an instrument, that great care is requisite in the choice of the crystals subjected to it for the admeasurement of their angles. It often happens that those of apparently the most beautiful surfaces are unfit for this purpose; the most clear reflections alone can be relied on, and even then only by comparing the results of trials on many crystals. Some of the first attempts gave an incidence of 2 on 2 over the apex of the fig. 27. Pl. 16. one way of 92°. 55'. the other way 93°. 20'. or even 93°. 25'. and this induced the suspicion that the bases of the two pyramids composing the primitive octohedron, were not square. The crystals on which those admeasurements were taken, were, comparatively, large, and their reflections were by no means so clear as those since obtained on much smaller ones, which have confirmed the real incidence both ways to be 92°. 55'. and therefore that the common base of the two pyramids is square.

The crystals of this substance are likewise subject to another difficulty, that of a double reflection, even on faces which, by the assistance of the lens, appear of the most perfect kind. I possess a crystal giving two reflections on three of the four faces, 2, 2 fig. 27. which are those of the pyramid commonly observed on the crystals of this substance. The incidence obtained one way over the apex, with the two strongest reflections was, 92°. 55'. with the two weaker 93°. 10'. but with a strong reflection on one face and a weaker on the other 93°. 5'. On one of the other two opposed faces of the pyramid, one reflection only was given, but on the other, two were visible; with the strongest reflection, the incidence obtained was 93°. 35'. with the other, 93°. 25'. the least of them 30'. above the real value of the angle.

sional exceptions certainly exist, reliance cannot be placed but on crystals so small, or rather so minute, as that it may reasonably be doubted whether it be possible for the most skilful hand to obtain with accuracy the admeasurement of the angles formed by the meeting of their facets by means of the common goniometer. The larger crystals are certainly best adapted to the use of this latter instrument, and hence, as I conceive, must have arisen, at least in part, the differences in the results obtained by it, and by the reflecting goniometer.

The admeasurement of the angle formed by the meeting of the planes 1 and 2 Fig. 27, Pl. 16. is prominently noticed by Haüy. This angle is first given in his Traité as 135°, and secondly in his Tableau as 133° 29′; the value of almost if not of every other angle in any degree connected with this, likewise differs very materially. These circumstances induce the supposition that having assumed the value to be first 135° and afterwards 133° 29′, the rest were arrived at by calculation in both instances, and if so, were, of course, dependent on the truth and accuracy of this single determination. It is not therefore surprising that they should be made to differ so essentially in the two works.

In attempting the admeasurement of the angle above noticed, viz. that of 1 on 2 fig. 27. Pl. 16. the reflecting goniometer I first employed, being graduated only to 5 minutes, never satisfactorily gave an incidence of 133, 30, or 133. 35, but generally approached as nearly to the one as to the other. This caused the suspicion that the true value lay somewhere between them, and induced the wish for a goniometer more highly divided; and I have obtained one graduated to half a minute, from Mr. Carey, whose ingenuity led him to add to it some apparatus with a view to precision in its use. By this instrument, I have repeatedly found the angle in question to be 133°. 32′. 30″.—being 1°. 27′. 30″. less than the former determination of

Haüy; and 3′. 30″. more than the latter. It may therefore be presumed that the value of other angles connected with this, as obtained by the reflecting goniometer, differ from those given by Haüy, both in the Traité and in the Tableau. I am perfectly aware that it becomes me to speak with great deference on this subject. I offer only the results of a mechanical attempt to ascertain the angles of this substance, being incapable of verifying or of detecting their fallacy by a recourse to calculation.

The angle formed by the meeting of the planes P P. of the primitive crystal, fig. 18. Pl. 15. is given by Haüy as 67° 42′; by the reflecting goniometer, I have uniformly obtained from clear reflections, an incidence of 67°. 50′. making a difference of 8 minutes.

The incidences subjoined, are, for the most part, the result of many perfect agreements of each, on different crystals. In no instance has an average result been noticed. All are not to be relied on with equal confidence. The plane forming the 9th modification of the primitive octohedron is always so striated, and those of the 3d and 10th, are always so dull, that the incidences of those planes with any other in the subsequent series can only be considered as approximations.

Incidence of	P on P fig. 18. Pl. 15 - - -	67°. 50′
————	P of either pyramid on its opposed plane over the apex	112°. 10′
————	1 on P fig. 21. Pl. 16 - - -	113°. 25′?
————	1 on 1 fig. 21 - - - -	90°.
————	1 on 2 fig. 26 - - - -	133°. 32′. 30″
————	2 on P fig. 26 - - - -	150°. 45′.
————	2 on 2 of either pyramid over the intervening edge, fig. 27	121°. 40′.
————	2 on its opposed plane 2, over the apex, fig. 27 -	92°. 55′.
————	2 on 2 over the plane 1, fig. 27 - - -	87°. 5′
————	3 on 2 fig. 33 - - - - -	136°. 35′.?
————	4 on P fig. 39. Pl. 17 - - - -	123°. 55′
————	5 on 1 fig. 49 - - - - -	151°. 35′

Incidence of	5 on 4 fig. 49 - - - - -	153°. 25′
————	5 on 5 over the plane 4 fig. 49 - - -	126°. 45′
————	5 on 5 over the plane 1 fig. 49 - - -	143°. 10′
————	6 on 1 fig. 60. Pl. 18 - - - -	168°. 40′
————	6 on 5 fig. 60 - - - - -	172°. 50′
————	7 on 1 fig. 66 - - - - -	155°. 25′
————	7 on 2 fig. 70 - - - - -	154°. 15′
————	7 on 7′ fig. 66 - - - - -	159°. 5′
————	7′ on 7′ fig. 66 - - - - -	118°. 10′
————	9 on 1 fig. 114 Pl. 20 - - - -	157°. ?
————	9 on 2 fig. 114 - - - - -	131°. 10′ ?
————	10 on 2 fig. 164 Pl. 22 - - - -	150°. 30′ ?
————	10 on 9 fig. 167 - - - - -	158°. 15′

Specific Characters.

Primitive crystal—an octohedron composed of two obtuse quadrangular pyramids joined at their bases, which are square.

Fracture—mostly shattery, often vitreous; sometimes conchoidal, sometimes lamellar.

Aspect—non metallic.

Specific gravity*—6,9009—6,9348 according to Haüy.
 of the crystallized grey tin-stone 6,84, Klaproth.
 of stream tin - - - - - - 6,56, ditto.
 of another ditto - - - - - 6,97, ditto.
 of wood tin - - - - - - 6,45, ditto.

Hardness—brittle and easily frangible; gives sparks with a steel.

* "It is remarkable enough that tin, which, in the metallic state, is one of the lightest metals, surpasses in specific gravity, when in the state of oxyd, the greater part of other substances of the same class, whether simple oxyds or composed of an oxyd with a mineralizing substance. The weight of oxydated tin is such, that its difference with that of metallic tin is but about one-twentieth at least; whilst other metals offer, in analogical instances, differences which amount to one-half or one-third." Haüy.

Electricity—the coloured portions, when placed in communication with an electrified conductor, emit bright sparks on the approach of the finger. Haüy.

Colour—whitish, either translucent or opake; it is sometimes of a resin yellow, but more often of a deep brown somewhat reddish, more frequently blackish, or black; occasionally brick-red, but in that case generally bears in some respect marks of having been exposed to the action of fire.

Transparency—the more colourless crystals are generally somewhat transparent, in which respect they sometimes almost equal common quartz.

Lustre—resinous or vitreous.

Dust—of a dull ash grey.

Analysis—77,5 tin, 21,5 oxygen, 0,25 oxide of iron, 0,75 silex. Under the blowpipe it decrepitates; becomes pale and opake; is reducible in part to a metallic state, but with difficulty. When heated and melted with glass, it imparts to it a milk white colour.—Brongniart.

Primitive Crystal.

The Abbé Haüy in his "Traité de Minèralogie" assigned the cube to the oxyd of tin as its primitive form, because he thought he "perceived the natural joints parallel with the faces of that solid, although they were not sufficiently determinate to remove all doubt." This opinion was combated by Mr. Day in a paper on this substance, published in an early volume of the Philosophical Magazine, in which he assumed as its primitive crystal an octohedron composed of the two quadrilateral pyramids commonly seen on the crystals of the oxyd of tin, joined base to base, being those of 2, 2. fig. 27. Pl. 16.

In 1809, a new work of the Abbé Haüy's made its appearance, entitled "Tableau Comparatif, &c." in which he says (p. 285) that a revision of his researches on the subject of the oxyd of tin, in consequence of his having obtained some crystals from Cornwall, proved to him that the true primitive form is, not as he formerly supposed, the cube, but a rectangular octohedron, of which the faces answer to o o, Pl. lxxx, fig. 179 and 180 of his former work, or, which is the same thing, to those of P P, fig. 26, Pl. 16 of the series attached to this paper. He says further, that the joints which gave this octohedron are extemely sensible on exposing fractures of tin to a vivid light; and again, that he has been led to the adoption of this octohedron as the primitive form by the results of mechanical division.

What the circumstances in the mechanical division of the crystals of this substance leading to this result were, have not been explained, but having been unexpectedly led to the same conclusion by the cleavages I have obtained, I shall proceed to describe them.

While preparing this paper, with a view of presenting it to the notice of the Geological Society, and while an attempt at the mechanical division of the crystals of the oxyd of tin was on my list of agenda, Dr. Wollaston informed me that he had succeeded in obtaining it, in a direction parallel with the faces of the prism, and I have since had the same success in numerous instances, so as to procure on the planes of the fracture an incidence of 90° by the reflecting goniometer.

Thus is the conjecture of Haüy before cited, that he perceived the natural joints parallel with the planes of the prisms verified. I have also obtained numerous cleavages parallel with the diagonal of the prism, but have in vain attempted it in a direction perpendicular to its planes.

In pursuing this subject, it occurred to me that the exposure of the crystals of this substance to the action of heat, might possibly lead to some further discoveries. Accordingly, some were placed in the centre of a common fire during an hour or two, and being afterwards left to cool I found that a slight touch with a hammer immediately reduced them into small pieces: a research among these afforded very many of the above cited cleavages, which I had previously obtained from crystals that had not been subjected to the action of heat.

Let fig. 1. Pl. 15. represent the cleavages, which are easily obtained parallel with the faces of the prism, and fig. 2 its diagonal cleavages. By a combination of all these in fig. 3, it will be seen that the prism is divisible into right-angled triangular prisms, of which I have numerous instances.

In pursuing a research among the fractures, I found several quadrangular prisms with oblique terminal faces, parallel with each other, as represented by fig. 4, and others similar to fig. 5; which it will be obvious differ only from each other in these respects, that the edges *f g* and *b c* are replaced by the planes *a* and *b*, and that the two other edges, *a d* and *e h*, are also replaced by similar planes, all which planes are parallel with one or other of the diagonals of fig. 4.

I have other fractures described by fig. 7, which are the result of a mechanical division of fig. 4 in the direction of its diagonal *a b* and *c d*, and along the edges *b c* and *a d*. It follows that fig. 7 is a right-angled triangular prism with oblique terminal faces, which in some of these fragments are perfectly brilliant.

If also a section of fig. 4 be made in the direction of its other diagonal, shewn by the dotted lines *e f* and *g h*, and along the edges *f g* and *e h*, it will be divided into four parts, one of which will be represented by fig. 8, which is a right-angled triangular prism with inclined terminal faces: several of these are in my possession.

The fractures represented by figs. 5, 7, 8, prove the mechanical division of the crystals of this substance, in the direction of both diagonals; and what has before been said of that in a direction parallel with the faces of the prism, would suffice without further proof. If however evidence were wanting, the cleavage described by fig. 6, decides its practicability beyond a doubt. Having placed in the fire a macle represented by the dotted lines of that figure, and of about the same size, I afterwards obtained from it a nucleus similar to the fig. *a b c d*, represented within it, and of about the same size, with faces well defined and very brilliant; it is now in my collection. This nucleus, it will be seen, is of the same form as that of the macle described by fig. 208, Pl. 25, and resulted from a cleavage of fig. 6, (which is of the same form as fig. 209) in a direction parallel with each of its six larger faces; and, as hereafter will be shewn in describing the formation of those macles, consequently parallel with the faces of the prism.

Among the fragments obtained from crystals that had been placed in the fire, I found some quadrangular prisms having one terminal face similar to that of the upper one of fig. 4, but with indications of the lower terminal face in the opposed direction as represented by fig. 9.

On applying the goniometer to the face P and along the edge *b c* of fig. 9, I was somewhat surprized at finding that there is no perceptible difference between their incidence on each other and that of the plane P, and along the edge *b c* of a crystal similar to fig. 11;

and in some instances I obtained perfect co-incidences by the reflecting goniometer between the faces P and *a* fig. 9. and those of P and *a*, fig. 11. having eight fractures of the figs. 4. and 9. which permit the use of that goniometer.

On three fragments similar to fig. 9. I have attempted a mechanical division in the direction of the small planes *a f e* fig. 10. and have succeeded in obtaining one or the other on each, so as to warrant the conclusion of the practicability of the whole. It will be noticed that if a division were still pursued in the direction of the planes *a f e*, the consequence would be that the planes on the summit of fig. 10 would become in form similar to those of P P fig. 11.

The cleavages obtained by the planes *a f e* demonstrate the possibility of a mechanical division parallel with each terminal face of a crystal similar to fig. 11. The probability of this in two out of the four directions may be argued from what is known respecting the formation of the macles of this substance.

It was long since determined by L'hermina that the common macle represented by fig. 186. Pl. 24. as will hereafter be further noticed, is the result of a section of a common prismatic crystal, fig. 27. Pl. 16. in a direction parallel with one or the other of the edges of its pyramid. The planes forming the pyramid of fig. 11. Pl. 15. are usually considered to be the effect of a decrement on those edges, but the reverse is the fact; for, by figs. 18, 19, 20, 21, 25, 26, 27, it will be seen that the pyramid of fig. 27. is the result of a modification of the primitive crystal described by the planes 2,2 on fig. 22; and it will be equally obvious that if the section determined by L'hermina be parallel with one or other of the edges of the pyramids of fig. 27. it must also be parallel with one or the other of the planes of the primitive octohedron, consequently with one or the other of the planes composing the pyramid of fig. 11. It will hereafter be shewn in describing the apparently dodecahedral macle, fig. 188. that it results from a section of the prism, both in the direction described by L'hermina, and in the opposite direction. Let these sections be described by the dotted lines, *b g d h* and *f g c h*, fig. 11.

Now, it may be noticed that by a practicable cleavage each way through the centre of a crystal similar to fig. 11. but parallel with the planes of the prism, it is divisible into four parts, similar in form to the fracture described by fig. 9. On one of these portions similar to that figure let the sections given on fig. 11. be represented by the lines *b g d h* and *c g d h*, fig. 12. and it will be seen that *a b c d* on that figure will represent a fracture similar to fig. 4. If this be pursued still further it may be observed by representing the lines of section *b g d h* fig. 12. on fig. 13. that by the parallel section *b c g*, a tetrahedron *a b c g* is obtainable.

The fragments represented by fig. 8. were obtained by a cleavage of others represented by fig. 4. in the direction of its diagonal *e i f*. If therefore a section of fig. 9. be made in the direction of that diagonal, one portion of that figure so divided, will agree in form with fig. 14. which figure exactly corresponds with one fourth part of a crystal represented by fig. 15. by a section along the edges both of the prism and the pyramids, the planes P P and *b* resembling each other. The planes P P and *b* fig. 15. also correspond with those of P P *b*, fig. 16. which planes are usually supposed to arise from a decrement on the edges of a crystal similar to fig. 27. Pl. 16.

I presume it has been satisfactorily demonstrated, that by the fractures represented by figs. 4, 5, 6, 7, 8, and 9, Pl. 15. a mechanical division of the oxyd of tin is unquestionably obtainable, parallel with the planes of the prism, as well as, by figs. 5, 7, and 8, with both its diagonals. I presume also that it has been shewn, by the agreement in the incidences of the plane P on the edge *b c* of the fracture, fig. 9. with the plane P on the edge *b c* of the crystal, fig. 11. as well as of the plane P with the plane *a* of each of those figures; that the plane P of the former figure, is really the result of a cleavage parallel with the plane P of the latter figure; and also, by fig. 10. that a mechanical division is equally practicable parallel with each of the four planes P, composing the pyramid of the crystal fig. 11. Let therefore all these cleavages be represented on fig. 15. and it will be seen that the result is a mechanical division of it into tetrahedrons.

It has already been said that in the first instance the Abbé Haüy, was induced to believe the cube to be the primitive form of the oxyd of tin, but that he was afterwards led to adopt the flattened octohedron composed of the two pyramids of fig. 15. joined base to base. In this latter opinion, there seems to me, from the evidence now offered, no room for doubting his correctness. For whatever has been said tending to shew a connexion between the fractures that have been described, and a crystal delineated by fig. 15. relates, with equal aptitude, to one having either a longer or a shorter prism, and equally well to one having no prism at all: for it will be seen by fig. 17. that the form of fig. 15. is merely the result of a decrement on the edges of an octohedron formed by the meeting of its two pyramids base to base; which octohedron is given by itself fig. 18. as the primitive form of the oxyd of tin. But it has not hitherto been seen unmodified; nor has any crystal been noticed approaching it more nearly than that delineated by fig. 21. Pl. 16.*

* On the subject of the integrant molecule I do not feel competent to say more, than that it has been already shewn, by a combination of all its known cleavages, that the primitive crystal is mechanically divisible into tetrahedrons; but as these tetrahedrons will necessarily be irregular or rather unequal in their form, it may not be satisfactory

*First Modification.**

This modification is represented by fig. 19. Pl. 16. and consists in a decrease on the four lateral solid angles of the primitive form, by which each is replaced by a plane, perpendicular to the axis passing through those angles.

Fig. 20. shews this modification in a more advanced state, and has been added not because it has been thus observed, but in order that the combination of the planes of this modification with those of the primitive form, may be the more readily traced in fig. 21. in which it occurs, though but rarely. In the fine collection of tins, in the possession of Mr. Sowerby, there is a specimen of

to adopt it as the integrant molecule. Indeed, it may fairly be doubted, whether, considering the present state of mineralogical knowledge, much benefit has accrued from the attempts that have been made to determine that of many other substances.

* The crystals of this substance, when on the matrix, have so greatly the appearance of being confusedly grouped, that little can be done towards describing them, on account of their splendour and numerous facets, without first detaching them from the matrix, which on account of their brittleness requires considerable care. The mode best adapted for preserving as well as for observing them, I first noticed in the scientific collection of the Count de Bournon, in which, insulated crystals are placed on wax. For this purpose I have used the common green taper cut into pieces of about an inch in length, and placed the crystal at one end. There are between 4 and 500 crystals of this substance so arranged in my collection, including every one described in the series belonging to this paper, and, being placed in that series according to the method adopted by the Count de Bournon (that is, according to their modifications) little or nothing need be said upon any of the individual crystals.

But in order to render the series more perfectly intelligible, I have taken especial care to place the drawing of every crystal throughout the series in the same point of view, except in a few instances, for the sake of illustration. I am aware that an attention to this circumstance affords material facility to those who may desire to become acquainted with the crystallization of the substance, in tracing the modifications through their various combinations: and the same care has been observed, not to introduce in the series of any modification, the figure of a crystal exhibiting the planes of any other modification, that has not preceded it.

considerable size, almost covered with well defined crystals represented by figs. 21. and 25.

Neither the planes of this, nor of any other modification have I believe been found in simple combination with those of the primitive crystal. They are thus given preceding the series of each modification, in the hope of thereby rendering each the more intelligible; to this I have generally added a figure representing their combination with the planes of the secondary octohedrons, being those of the second modification, because the planes of that modification form the pyramid most commonly found on the crystals of this substance.

Second Modification.

Each of the four solid angles formed by the meeting of the two pyramids of the primitive form base to base, is by this modification replaced by two triangular planes; each plane being placed on an edge of the pyramid, but inclining on the axis passing through the solid angles, fig. 22. Pl. 16.

This modification is represented in an advanced state, by the dotted lines of fig. 23. shewing by the lines within it, that when complete, it produces a secondary pyramid considerably more acute than that of the primitive form. The secondary pyramid produced by this modification is that commonly observed on the crystals of this substance, and by fig. 24. is represented within the dotted lines of the primitive form.

Fig. 25. shews the first and second modifications in combination with the planes of the primitive crystal. The lines on the faces of this figure denote the direction in which the striæ are sometimes to be observed on the crystals.

Fig. 26. shews the passage into the secondary pyramid, which is complete in fig. 27.

Fig. 28. represents an elongated crystal; its elongation proceeds from a regular deposition of crystalline laminæ on one face of the upper and on one of the lower pyramid, and on the intermediate plane of the first modification. On the crystals represented by fig. 29. a deposition of laminæ has taken place on two opposed planes of the first modification, gradually diminishing, so as to preserve the lengthened faces of the second modification perfect planes. On fig. 30. this species of deposition has taken place, after the crystal itself had been formed similar to that of fig. 28. Fig. 31. shews a crystal on which a regular deposition has taken place on two opposed faces of the upper and the two corresponding faces of the lower pyramid, so as to diminish two of the four triangular planes of each, and to give the other two the form of irregular hexahedral planes.

Third Modification.

This modification consists in a decrease on each apex of the primitive form, by which each is replaced by a quadrangular plane, perpendicular to the axis passing through the apices, Fig. 32. Pl. 16. The planes of this, though not uncommonly found in combination with those of other modifications, are rarely so well defined as to be depended on for accurate admeasurement, owing to an unevenness on their surfaces. I have not succeeded in finding crystals that have satisfactorily allowed the incidence of the planes of this modification with those of the primitive form.

Fourth Modification.

This modification consists in a decrease on each of the edges of the primitive crystal, formed by the meeting of the two pyramids base to base, by which each is replaced by a plane, perpendicular to the axis passing through those edges, fig. 34. Pl. 17.

The planes of the primitive crystal are rarely found in combination with those of this modification, except when they seem only to be the result of a decrease on the edges of the secondary pyramid as in fig. 39. Fig. 35. shews the combination of the planes of this modification with those of the secondary pyramid, which is thus given, because, as the secondary pyramid is that commonly observed on the crystals of this substance, it seems to facilitate the tracing of the various combinations in the succeeding figures.

Fifth Modification.

The fifth modification arises from a decrease on each of the solid angles caused by the meeting of the two pyramids base to base, by which each is replaced by two triangular planes placed on the edges formed by the meeting of the two pyramids, but inclining on the axis passing through the lateral solid angles, fig. 45. Pl. 17.

The planes of the primitive crystal are also shewn by the dotted lines of fig. 46. together with the planes of this modification in a more advanced state. The latter are also exhibited in combination with those of the secondary pyramid, by the lines within that figure.

It will be noticed how nearly the crystals given by fig. 55. approach the cube, and that of fig. 47. the secondary octohedron. The crystal represented by the latter figure does not exceed in size the head of a small pin, but all its planes are remarkably brilliant and well defined.

Sixth Modification.

This modification, like the preceding, consists in a decrease on each of the solid angles, caused by the meeting of the two pyramids of the primitive form base to base; by which each is also replaced by two triangular planes placed on the edges formed by the meeting of the two pyramids, but inclining on the axis passing through the angles, more than those of the fifth modification, fig. 58. Pl. 18. The planes of this modification are shewn in combination with those of the primitive form by the dotted lines of fig. 59. and with those of the secondary octohedron by the lines within it.

Seventh Modification.

This modification consists in a decrease on each of the four solid angles caused by the meeting of the two pyramids of the primitive form, by which each is replaced by four triangular planes, placed on the faces of the primitive form, but inclining on the axis passing through the lateral solid angles, fig. 63. Pl. 18.

By fig. 64. the planes of this modification are shewn in a more advanced state, which renders the first figure in the series, that of 66, perfectly intelligible. Fig. 65. shews them in combination with the secondary pyramid, and will, without pursuing the series from fig. 66. to fig. 70. cause the latter figure to be at once understood.

I have not satisfactorily obtained the incidence of the planes of the primitive form with those of this modification.

The principal part of the crystals delineated in the series of this modification, in which the prism is long and the facet of the 7th modification is small, are from Relistian tin mine, and are about a line in thickness. I have not seen them from any other mine.

The crystals represented by figs. 66, 68, 69, 70, 71, 79, are about the size of a common quill, and were presented to me by a gentleman of Penzance, who knew not whence they were brought; judging, however, from a superb specimen in my collection, on which there are some of the above varieties in form, and of about the same size, and which is from Gavrigan stream works in St. Mewan, I presume them to be from the same place.

The crystals delineated by figs. 72, 73, and 86, are singularly beautiful, and present, though scarcely a line in length, both terminations complete. They were all taken from the same specimen, which is the only one of the kind that I have seen, but from what mine it was brought I am unable to say, it having accidentally been left in London by the captain of a Cornish trading vessel. The crystals represented by fig. 67. were found detached in a vein near the Land's End.

Of the singular variety, fig. 98. I have four crystals, their form is occasioned by the elongation of one plane of the second modification on one pyramid, and of the opposed face on the other; they are of a light brown colour, and translucent.

Eighth Modification.

This modification, like the preceding, consists in a decrease on each of the four solid angles, caused by the meeting of the two pyramids of the primitive form, by which each is replaced by four triangular planes, placed on the edges, but inclining more than those of the preceding modification on the axis passing through the solid angles, fig. 106. Pl. 20. By fig. 107. the planes are shewn in an advanced state.

The two figures which alone compose the series of this modification, exhibit its planes very differently, and on all the crystals represented by these two figures, they are so uneven, or irregularly striated, as to render it wholly impossible to subject them to the reflecting goniometer. This modification is extremely rare. The crystals described by fig. 108. have I believe been brought only from the mine called Huel Fanny, west of Redruth.

Ninth Modification.

By the ninth modification, as well as by the second, each of the four solid angles formed by the meeting of the two pyramids of the primitive form, is replaced by two triangular planes, placed on the edges of the pyramid, and inclining on the axis passing through the solid angles; but in this modification they incline more on that axis than those of the second modification, fig. 110. Pl. 20.

Fig. 111. shews the planes of this modification in a more advanced state; and fig. 112. shews them in combination with the secondary pyramid. They are generally so minute or so considerably striated, as to prevent their incidence either with the planes of the primitive form, or with those of any other modification, from being satisfactorily obtained.

The greater part of the crystals delineated in the series of this modification, of which the planes of the first modification are long, and on which those of the seventh modification are observable, were taken from the surfaces of rounded portions of grauwacke, found in the hollow parts of the vein in Relistian mine. I have not noticed any macles on the specimens from that mine; all the crystals from it are nearly black, and of remarkable brilliancy.

Tenth Modification.

The planes of this modification replace the lateral solid angles of the primitive crystal, in the same manner as those of the second and ninth, but are still more inclined on the axis passing through those angles, fig. 155. Pl. 22. By fig. 156. the planes of this modification are shewn in a more advanced state, and by fig. 157. in combination with the secondary pyramid. Although the planes are of considerable size on many crystals, they are generally rough, or so much rounded, as hitherto to have prevented my obtaining a satisfactory admeasurement of their incidence on the planes of any other modification.

The crystals represented by figs. 158. and 159. were I believe found loose in a vein near the Land's End. Those of figs. 160. and 162. are from Huel Fanny. That of fig. 166. from Gunnis lake mine: it is about three quarters of an inch in length, and is perfect at both terminations. The crystals delineated by figs. 163, 164, 167, 168, 169, 170, and 171, are from Relistian mine. On the crystals, fig. 167. the planes of the first, sixth, and tenth modifications were evidently the consequences of a second deposition, as their natural joints with those of the fourth and ninth modifications are visible on every side.

Eleventh Modification.

This modification consists in a decrease along the edges of the two pyramids of the primitive crystal, by which each is replaced by a plane; fig. 172. Pl. 23. This plane, by a deeper replacement of those edges, would produce, it will be evident, another and more obtuse octohedron, fig. 173, the apices of which are visible in combination with the planes of the primitive form, and with those of the first and second modifications in fig. 174. I regret the not having been able to ascertain the incidence of the planes of this on those of any other modification.

All the specimens on which I have noticed the planes of this modification, were long since brought from Cornwall, but from what mine it is impossible now to ascertain.

Twelfth Modification.

The twelfth modification consists in a decrease on those edges of the primitive crystal which are formed by the meeting of the two pyramids base to base, by which each edge is replaced by two planes, placed on the primitive faces, but inclining on the axis, passing through the edges, fig. 182. Pl. 23. By fig. 183, the planes of this modification are represented in combination with the secondary pyramid, as will be evident on consulting fig. 184, which, together with fig. 185, represents the only crystals on which I have noticed the planes of this modification. I have not been able to ascertain their incidence on those of any other.

Macles.

Most of the crystals delineated in the series annexed to this paper, are defined with great neatness and beauty: but there is generally much seeming confusion among the crystals of the oxyd of tin, arising principally from a circumstance or law, not altogether peculiar to it, by which similar portions of two or more crystals are regularly united, so as to form what have been termed *macles*, one of which has been described by De Lille by that name, and by Haüy by that of *hemitrope*. The seeming confusion produced by the macle,* is very often much augmented by circumstances apparently resulting from no law, by which parts of crystals are jumbled together, so as to form a whole, that can only be understood by a long and patient investigation, which in the end serves only to satisfy the observer of the absence of all regularity in the disposition of the several constituent parts, although each may be separately defined.

But even the regular macles of the oxyd of tin seem, at first sight, to form no very intelligible part of the series of its crystallisation, although they are in fact very interesting. To understand them it needs only to become well acquainted with some of the most simple; as, for instance, with those of figs. 186, 187, 188, and 189, Pl. 24, which will serve as a ready clue to the comprehending of all such as are of regular formation; and by these it will be seen that they all proceed from the same law of section.

The macle first described by De Lille, who ascribes to Lhermina the developement of the law by which it takes place, is that of fig. 186, and will be understood by referring to fig. 190, on which the dotted lines *a b c d e* represent a section of it, parallel with the edges *e f* of the upper and *g h* of the lower pyramid† dividing the crystal into two parts. The upper part is represented in the same

* I have retained the term *macle* in preference to that of *hemitrope*, because the latter does not in fact apply to any one of them. It does not seem to me that the term *macle* is objectionable, because it has been given to a *substance*. In this case it only denotes a *circumstance*, and no one would think of asking for macles, without adding, of tin, of the ruby, &c.

† The section by which this, as well as the succeeding macles, takes place, being parallel with the edge of the secondary pyramid, it follows of course, as a reference to the series of the second modification will shew, that this section must also be parallel with the faces of the primitive octohedron.

direction in fig. 186, and the same proportion of another crystal having been turned half round, and reversed in its direction, is, in that figure, thus attached to it. The incidence of the edge *a b* on the edge *c d*, fig. 186, is 112°. 10′.*

The series of this macle, which is the most simple of all in its combination, is described by figs. 203, 204, 205, and 206, Pl. 25; and as the planes on each are numbered with those of the several modifications to which they respectively belong, they will be readily understood, except perhaps that of fig. 206. This latter, as a reference to fig. 52 will evince, is composed of similar parts of two crystals; but as the section of the two portions of which it consists took place parallel with a face P of each, which do not appear in the macle itself, it follows of course, that this section must be immediately opposed to that of the three preceding figures. The existence of this section will be explained and confirmed in speaking of the formation of the macle described by fig. 188.

Double Macles.

The macle described by fig. 184, Pl. 24, may be termed a *double macle*, because it is terminated at each end by a macle similar to that described by fig. 191, which resembles that described by fig. 186, except that the planes 1, 1, which are those of the prism, are shorter.

If we were to suppose fig. 187 to consist of two macles similar to fig. 191, simply reversed, it would be obvious that a re-entering

* The Abbé Haüy in his Tableau comparatif, has given this incidence, as 112°. 16′. 44″, but I have been induced to quote it as above, because I have uniformly so obtained it by means of the reflecting goniometer, on macles having the edges *a b* and *c d* replaced by the planes of the fourth modification.

angle, described by the dotted lines, must exist between the planes 2, 2, of each, which are those of the second modification; instead of which the whole space between those planes is occupied by an elongation proceeding from each, so as to connect and form the two upper planes, 2, 2, into one plane; the same effect takes place in regard to the two lower.

The series of this double macle is given by figs. 216 and 221, Pl. 25, placed in the position in which they are most commonly found: they usually present but one termination, the other being imbedded in the matrix. Fig. 217, represents a crystal similar to that of fig 190, but with a shorter prism, so placed as to shew most advantageously the section described on fig. 190, and thereby serve as a clue to the more ready comprehension of the series. On each figure the planes of the several modifications are pointed out, by the number of the modification itself being placed on them. On figs. 218, 219, and 221, the planes of the primitive form are visible. These macles are generally defined with great neatness, and mostly allow of the perfect use of the reflecting goniometer, which has been employed to corroborate what has been said of their construction, the truth of which it places beyond a doubt. I possess macles represented by figs. 218 and 220, on which both terminations are complete.

Incidence of 4 on 4, on the summit of fig. 218—112°. 10′.

This macle seems to verify the conclusion of Lhermina, that the section *a b c d*, fig. 190, takes place parallel with the edges *e f* and *g h*, which are those of the secondary pyramid. If the terminations *k k* of fig. 187, were complete, or, in other words, if the planes of the second modification were not visible, fig. 187 would take the form of fig. 192. Of fig. 192, let a section along the edges *a b* and *c d*, be represented by fig. 193, and the dotted line *e f* will represent the line of junction of the upper and lower parts 1, 2, 1 and 1, 2, 1 of fig. 192, and consequently also the plane of section *a b c d*, of fig. 190, which being parallel with the secondary edge *e f* of that figure, is therefore parallel with the planes of the primitive form, as a reference to figures 18 to 27, Pl. 16, will evince. In place of the edge *a b*, fig. 192, which is the edge of the secondary pyramid, the primitive plane P is seen on fig. 218, Pl. 25, which plane gives on its opposed plane P of the same figure (not visible on the figure, but which, as it were, replaces the edge *c d* of fig. 192) by the reflecting goniometer an exact incidence of 180°. It follows of course that the edges *a b* and *c d*, fig. 193, are parallel with each other; and also that the intermediate line of section *e f* must be parallel with each, and therefore with the edge of the secondary pyramid *e f*, fig. 190.

For the discovery of the construction of that macle of the oxyd of tin, which, when viewed in the direction in which it generally occurs, and in which it is delineated by fig. 188, Pl. 24, appears to take the form of a dodecahedron with triangular faces, I was principally indebted to the direction of the striæ on its planes. Having noticed them to be mostly visible as described on that figure, a suspicion arose that this macle was composed of equal parts of the prism formed by the planes of the first modification, and I found by the common goniometer that the incidence of any plane of the upper, on its connected plane on the lower pyramid, exactly corresponded with that of 1 on 1, fig. 27, being 90°. The idea of its being composed of similar and equal portions of several crystals, was further corroborated by observing, in almost every instance, their natural joints along the edges from one apex to the other.

This apparently dodecahedral macle, fig. 188, Pl. 24, at first sight, seems to have no analogy with the preceding macles, but that it results from the same law of section as those described by figs 186 and 187, may be readily shewn. Let the section *a b c d*, fig. 190, which is parallel with the edges *e f* and *g h* of that figure be represented by a section *a b c d*, fig. 194, parallel with the edges *e f* and *g h* of that figure; then let *e b h d* be a section in the opposite direction parallel with the edges *f a* and *e g*. By placing the prism so that the edge *k b i* of fig. 194 shall be represented by *k b i*, fig. 195, it will be seen that the lines of section *a b c d* and *e b h d* are the same on each figure, and that by these sections two equal portions *b h d a* and *b c d e* are obtained from the prism, the former of which is shewn by fig. 196; and it will also be seen that the planes 1, 1, of the latter figure, correspond with those of 1, 1, fig 188. It will be understood therefore that this macle consists of a number of equal portions of the prism, described by fig. 196, and that the planes of the first modification alone are visible.

But there is a circumstance relating to the formation of this macle that deserves attention. If it were, as it seems to be, a dodecahedron with triangular faces, the two pyramids, of which it would be composed, being divided horizontally, would each have for its base a regular hexahedral plane, divisible into six *equilateral* triangles, fig. 197, and the six angles of the plane would necessarily be 120° each. If a diagonal section of a crystal, fig. 194, be made along the edges of the pyramids *e f a* and *c g h*, and along those of the prism *e c* and *a h*, the plane given to each portion by that section would also be a hexahedral plane, fig. 198. But since it has been shewn that the two sections on fig. 194, (represented by the lines *a i c* and *e i h*, fig. 198) are parallel with the edges *e f* and *g h*, and *f a* and *e g*; and since the incidence of the edge *e f*, on the edge *f a* over the apex of the crystal, is 112°, 10′, and that of *f a* on *a b* 123°, 55′, it will follow that the triangular planes *a i b* and *e i c* are not *equilateral*, but *isosceles*, triangles, of which the outer sides *a b* and *e c* are the longest, the two others being equal. Now, six isosceles triangles, similar to those of *a i b* and *e i c*, fig. 198, are not equal to the complement of a regular six-sided plane, fig. 197, as will be seen by fig. 199. The macle delineated by fig. 188, therefore cannot be a regular dodecahedron with triangular faces. By an attentive examination it will be generally found to exhibit only three or four sections of the prism similar to fig. 196 : and although this circumstance is commonly attributed to interrupted crystallisation, that is not in fact the cause of its assuming that appearance.

In my collection there is a macle obligingly presented to me by Mrs. Lowry, of about half an inch in diameter, and almost perfect, which as it demonstrates that six sections of the prism, fig. 196, are not equal to the complement of the dodecahedron, is highly interesting. It is represented by fig. 189, which shews, that instead of exhibiting, as in the preceding figure, equal and similar planes 1, 1, of equal portions of fig. 196, it has only 3, each of them, alternating with facets of another form, having between them a re-entering angle.

Let fig. 201 represent a close combination of three isosecles triangles, *a b c*, *a c d* and *a d e*, similar to those produced by the lines of section on fig. 198. Then let *a f c d g* represent one of those triangles, and one-half of each of the other two. By comparing the plane *a f c d g* with *a f c d g* of fig. 200, which is the plane that would be the base of each pyramid of the macle described by fig. 189, by a section between them, it will be seen that there is a perfect agreement between each ; and it will also be seen that *a b i k g* and *a b l m f* are similar planes, each consisting of one isoscele and two halves, of similar triangles. It follows therefore that this macle is composed of three sections of the primitive prism, fig. 196, alternating with six halves, two and two, of the same figure.

It should be noticed that the angle *l m c*, fig. 200, to which there are five others similar, is about 120° by the common goniometer; but as the edges of the macle are very uneven, it cannot be relied on for admeasurement. The angle *l m f*, like which there are also five others, nearly agrees, but is not accurate for the same reason with that of *a e c*, fig. 193, which is the result of a close combination of two similar isosceles triangles.

It will be understood that fig. 208, Pl. 25, and the seven succeeding figures, comprehending the series of that which is commonly termed the dodecahedral macle, (each being numbered with the figures of the several modifications of which it shews the planes) are not intended to represent dodecahedrons, as the macles themselves consist only of what is visible in the respective drawings, or at most of only one-third more, that is, of three or at most of only four sections of the prism, fig. 196, Pl. 24. Yet the apices of several of them are perfect, as for instance, the plane on the summit of fig. 210, which is perfectly defined, and which therefore indicates the regular combination of six sections of that figure, unitedly exhibiting a decrease on the apex by the plane of the fourth modification. As a corroborative proof, however, that these macles, under the most favourable circumstances for perfect crystallization could never become perfect dodecahedrons, it may be observed that several in the series which exhibit those planes of the fourth modifications which give to fig. 210 the form of a short prism, give uniformly an incidence of 4 on 4 by the reflecting goniometer of 112°. 10′.; whereas if they were perfect dodecahedrons, the incidence would necessarily be 120°. Supposing the macles represented by fig. 188, pl. 24, or fig. 208, pl. 25, to consist of four sections similar to fig. 196, the plane that would be given to the upper and lower faces by a horizontal section, would resemble fig. 202, the angles of which are 112°. 10′, and it will be obvious that this figure could not be made to agree with the plane of section of the perfect dodecahedron fig. 107, the angles of which are 120°, by adding to it triangles of a similar description.

Macles of Macles.

The figures in this series occupying pl. 26, are extremely complex, as except the latter, each consists of four, or a greater number of similar parts of some one of the macles already described, for which reason I have termed them *macles of macles.*

That which is described by fig. 222, Pl. 26, consists of four similar parts of macles, fig. 188, Pl. 24, which by fig. 223, Pl. 26, is placed in such a position as to shew that section of fig. 188, which forms one-fourth part of fig. 222, as will be readily seen by noticing the figures 1, 1, on each, the planes on which they are placed, being those of the first modification, or in other words, of the common prism. The striæ on these macles uniformly take the direction given by the lines on fig. 222. I have several that shew both terminations, and the natural joints of the four portions of which they are constituted are always visible on the direction of the stronger lines down the center of the faces of what may be termed the prism of the macle. As the incidence of the planes 1, on 1 of this macle, give by the common goniometer exactly 90°, it follows that a horizontal section of this macle would give a square plane to each part so divided. Let this plane be represented by fig. 224, Pl. 26, and as fig. 222 is composed of four equal parts of macles similar to fig. 223, it will follow that the lines *a*, *b*. and *b*, *c*, fig. 224, will represent that portion of the whole plane, occupied by the constituent part of one macle, and further, the lines of section, *a b* and *b c*, being perpendicular to the lines *a d* and *c d*, that the section of each of the four macles constituting that described by fig. 222, takes place parallel with the planes of the common prism; and it has been shewn, in treating of the primitive crystal, that in this direction a cleavage is easily obtained.

Those described by figs. 225 and 226 differ only from fig. 222, in this, that the planes of some other modifications are visible, the respective numbers of which are placed on them.

That described by fig. 227, consists of four macles similar to that delineated by fig. 211, except that in this, each is elongated in the direction shewn by fig. 228. Fig 229 represents one composed of four elongated macles fig. 214.

By fig. 230, Pl. 26, is represented a singular combination of the four macles composing the preceding figure, placed on the edges of the prism of a crystal similar to fig. 42, pl. 17. This combination may be quoted in evidence to the truth of what has been said of the construction of common macles, for it will be observed that the faces 1, 1, on the prism of the crystal itself, and on the macles placed on its edges, are all planes of the first modification. Both terminations of fig. 230, as well as of the two preceding figures are visible on the macles.

Fig. 231, Pl. 26. represents a macle composed of 16 portions of the prism, fig. 196, Pl. 24, each elongated, the whole forming an octangular prism, of which a horizontal section is described by fig. 233. The striæ are uniformly in the direction represented. The construction of this macle will be obvious by consulting fig.

234, by which it will be seen that the triangular faces correspond with those of 1, 1, fig. 232, which is that of a common prismatic crystal, fig. 27, Pl. 16, placed in such a point of view, as most easily shews the section shewn on fig. 194, Pl. 24. Each of the eight solid angles of this figure, therefore, is composed of two portions of the common prism, fig. 196; giving, by the common goniometer, along the edges *a b c*, an angle somewhat more than 112°, which, generally speaking, is the same as that *l m f*, fig. 200; the plane 1 on 1, over the edge between them, which is that of the common prism, also gives an incidence of 90° corresponding with that of the planes 1 on 1, fig. 196. That part of fig. 234, comprehended within the dotted lines, is supplied in the macle itself, by an elongation proceeding from the upper and lower triangular planes.

Fig. 235, Pl. 26, represents a macle, in which two halves of one similar to fig. 218, are attached so as to give an incidence of the planes P on P, which are not visible in the drawing, but which are parallel with the planes P P, which are given, of 112°, 10′, by the reflecting goniometer, over the angle between them, corresponding with that of the planes 4 on 4 on the summits of the same figure, and of course with that of the planes 4 on 4 on the summits of fig. 210.

This appears as blackish streaks in the ash-coloured marl, much resembling in form some plant. They frequently project above the surface, being a little more compact than the marl, though they are also calcareous; they lie in all possible directions, exhibiting sections sometimes at right angles to their axis, sometimes oblique, and sometimes longitudinal. Their stems appear to have been hollow, and they have some parts attached to them extremely thin, like leaves. I found nothing like bulbs or heads to these. They are also very extensively distributed, occurring at every place where I observed this stratum.

J'ai fait un extrait en françois de 6 pages des cinq feuilles qui ont été déchirées dans cet endroit par quelque mal-intentionné.

XVIII. *Miscellaneous Remarks accompanying a Catalogue of Specimens transmitted to the Geological Society.*

By J. Mac Culloch, M.D. F.L.S. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich. V. Pr. Geol. Soc.

Having had an opportunity during the Society's late recess of collecting some specimens of the mineral productions and rocks of Scotland, I have transmitted them with a hope that other members who may have the means of so doing, will make still greater exertions in aid of this very necessary department of our museum. Such collections, however useless in an insulated state, acquire a real importance from their union, and form by their accumulation one of the leading objects of such an institution, a point of reference for authority whether geographical or mineralogical.

To these specimens I have been induced to add the miscellaneous remarks which form the present paper, with a view of attaching to them more interest than would accrue from the mere mention of a naked *habitat*, and for the further purpose of rendering the catalogue which must accompany them, more intelligible. These remarks include such geological observations on the nature and connections of the rocks from which the specimens were detached, as occurred to me at the time, or were the result of comparison with the observations of other writers who have treated the same subjects. Where the specimens themselves are deficient in the requisite purposes of elucidation, the references to the places where they were found will enable future visitors to verify or correct them. In this view the remarks which I have hazarded are even more necessary than in that of perfecting a catalogue of hand specimens, since of many important geological facts, it is impossible to preserve a sufficient record in a mere collection of rocks. A great portion of the country which is the subject of this miscellaneous notice, has been already surveyed by various geologists, and particularly by Professor Jameson in his tour to the Western Isles. Those who are accustomed to geological investigations will be as little surprised to find me occasionally differing from those observers as I shall be to find future observers differing from me. The science is as yet far removed from the class of accurate ones, and must still owe a great deal to that free enquiry which alone can lay the foundation of a precise and stable induction. It is peculiarly necessary in its present state that the labours of many should co-operate, as the wide diffusion and difficult accessibility of its leading facts put it out of the power of any single observer to add much from his own stock.

To the more extended geological remarks which seem to be called for by the peculiar circumstance of some of the rocks included in the catalogue, I have added a few words on specimens which scarcely involved any novelty either of a mineralogical or geological nature. Yet it will not be useless to describe their situation, since our Society among other objects offers itself as a deposit of miscellaneous information on those subjects, and of such detached facts as must otherwise perish in the portfolios or memories of those whose fortune it has been to notice them. It is not one of its least advantages that it forms a school of practical knowledge for those whose opportunities are circumscribed by the scarcity of scientific institutions or schools of this nature, and with this view, even the humble offering of a new *habitat* is deserving of record.

In the mass of geological reading which is in the hands of every one, most of the places referred to for characteristic examples are in foreign countries, always of difficult access to the many, and rendered more so at present from the circumstances of the times.

Our own country, perhaps, exhibits a greater variety of mineralogical products and geological facts than any equal space on the globe, condensed in their position and easy of access. It is desirable therefore that a record should be kept of such circumstances, that the student may not be sent to Siberia or Bohemia for that information which he may acquire in Arran or the Grampians; and that the humble task of recording the domestic *habitats* of interesting particulars may be countenanced by a Society which we trust is destined to add somewhat to the interest already taken in this pursuit, and to the general progress of geological knowledge.

In matters of terminology I have felt an inconvenience not peculiar to myself, which I have been unable to remedy without appearing to attack hypotheses that I would willingly have let alone, as the language of controversy is unpleasing, and appears rather calculated to retard than promote the progress of an infant science; not only by warping the impressions which the mind receives, but by diverting it from legitimate observation to the more amusing occupation of attack and defence.

I allude here chiefly to Werner's great divisions of rocks. If we describe the several rocks by the terms which he has applied to them, we begin by admitting the very matter to be proved. A worse consequence follows; the adoption of the terminology insensibly leads to a belief in the hypothesis, and becomes inimical to that independent and free spirit of observation which the infancy of any physical investigation more especially requires. To describe appearances without adopting this systematical language requires a circumlocution which it would be desirable to avoid, yet till either a system is firmly established on a wide and fair induction, or a set of terms can be produced independent of all system, such circumlocution is perhaps inevitable.

I have only to add, that since the following remarks did not admit of any useful or methodical arrangement, they are placed with little regard to order, and as the subjects of them occurred. That they are so detached, and often so superficial, must be imputed partly to want of knowledge, partly to want of time, and still more to the uncontroulable elements, to which the best laid projects of the mineralogist as of the husbandman must bend.

Rona.

I should scarcely have introduced any remarks on Rona, were it not for the purpose of mentioning that wolfram, hitherto unnoticed in this spot, is found in the granite veins that traverse the gneiss of which this island is principally formed. I may however remark at the same time, that these veins exhibit that variety of granite called graphic, a rock of much more frequent occurrence than it was once supposed. The graphic granite of Rona is distinguished by the great size of the crystals of felspar which enter into its composition, and consequently by the equal magnitude and distinctness of the quartz which fills their intervals. An accurate survey of Rona is still a desideratum for future mineralogists, as the number, magnitude, and peculiar character of the granite veins might give us hopes of detecting in them some of the rarer minerals known to be inmates of such veins, and observed in similar situations in other parts of the earth. I cannot however dismiss this subject of

Rona without pointing out to future observers the singular contortions exhibited as well by the gneiss as by the hornblende rock where they come into contact. I may also venture to suggest that the rock of Blue Bay, described as a mixture of hornstone, chalcedony and quartz, appears to be a modification of gneiss, exceedingly intersected by veins of quartz and felspar, and probably of granite. It exhibits no genuine hornstone; that part of it which has at first sight this appearance, being an intimate mixture of quartz and felspar. The chalcedony too is only that modification of quartz which occurs in graphic granite, and which is well characterized by its peculiar waxy look. Exposure to the weather produces on its surface a glossy enamel, of an opacity and lustre still more nearly resembling that of chalcedony, but which does not penetrate into the stone. A similar enamel is to be observed investing the sandstone of Jura and of Schihallien, and I have also specimens of the granite of Rockall, which exhibit the same appearance. It seems to arise from a partial solution of the silex on the surface, and has been observed in certain foreign sandstones, being quoted as an instance of the solubility of silex in water. This quartz occasionally assumes a high red hue, which is evidently to be traced to the penetration and intimate mixture of red felspar. In some places it is of a green colour, being penetrated by threads and laminæ of a substance bearing a resemblance to steatite rather than to hornblende. It thus forms a greenish stone, probably different from quartz coloured by actinolite which is called prase, from the same stone penetrated by epidote which has obtained no name, or from quartz tinged by green earth, which occurs in Rum and which, as well as chalcedony when similarly coloured, is known by the name of heliotrope. Yet, as it possesses the external characters and aspect of prase, it may be safely referred to a species of which colour seems the only very discriminating character. I think it necessary also to mention that the hornblende rock exhibits the two subordinate varieties of hornblende slate and greenstone slate.

Since I have already indulged in some cursory remarks on that sort of nomenclature which tends to mislead, by confounding substances, I may be excused for suggesting a reformation in the terms primitive greenstone and greenstone slate. These consist of mixtures of felspar and hornblende, in the latter case disposed in a laminated form, and in the former without that regular structure. Their title to greenstone, as far as colour is concerned, is still less than that of the varieties of the trap family, as the felspar is (in Scotland at least) always of a red colour. By the use also of the term greenstone, and by the series which is formed of primitive, transition, and floetz greenstones, the mind is naturally led to look for a geological and natural connection between these rocks. But the primitive greenstones belong to that class in which gneiss and mica slate form the principal features, and which constitute that great system of rocks of which hornblende in its several modifications of hornblende rock, primitive greenstone, hornblende slate, and greenstone slate, is only a subordinate and occasional member. The geological character of the flœtz greenstones, is their independence with respect to the rocks with which they are associated, and their intrusion, if I may so call it, among a regular system of stratified bodies. The transition greenstones are, I conceive, of a character merely arbitrary, and only so called because occupying the same situation with regard to the *transition*, as the former do with regard to the *flœtz* rocks.

Thus also, greenstones may be classed among the primitive, where they occupy similar positions among primitive rocks.

But the primitive greenstones to which I now allude, and which constitute a class of rocks entirely different, have been evidently formed together with the rocks which they accompany, and are, like them, referable to the same epoch, never intruding to their disturbance, but occupying situations and maintaining characters, in every respect conformable to them. It would tend to the accuracy of geological language, if they were to receive designations derived from their simple parent, hornblende rock, and it is to be desired that the occasional mixture of felspar with hornblende, whether that rock be massive or slaty, should be designated by a term, if it requires a distinct one, derived from its true basis, so as to prevent the confusion which their present names introduce into our ideas and descriptions.

Shiant.

The Shiant isles having escaped the notice of mineralogists, I shall make no apology for giving such a cursory description of them as my opportunities of observation allowed me to draw up, for the purpose of explaining the specimens which I have transmitted.

These islands are situated to the north of Ruhunish point, in Sky, from which they are distant about 15 miles, and they lie about 8 miles nearly south-east of the entrance of Loch Brolum, in Lewis. There are three principal islands, forming a nearly equilateral triangle, besides a few subordinate rocks of considerable height, but of small superficial dimensions. The names of the three largest are Gariveilan, Eilanakily, and Eilan Wirrey. Of these the two former are about a mile and half in circumference, and the latter appears to be less than a mile. They constitute one farm, the house appertaining to which is situated on Eilanakily. In approaching them on any side they exhibit high columnar precipices, surmounted by grassy irregular plains, and surrounded by rocky shores of difficult access, which are whitened by a rapid and generally turbulent sea. It is easy to perceive that they are all of a trap *formation*, and with that general knowledge of two of them, Eilanakily and Eilan Wirrey, I was obliged to remain content, as a gale of wind with thick weather coming on soon after I landed on Gariveilan prevented me from extending my examination further, without endangering the boat and her crew. I trust that some future mineralogist, with better fortune, may complete the investigation which I was obliged to leave undone, and fill up the blanks which will be found in my brief account of this very picturesque and interesting spot.

The boat landed in a bay on the north side of Gariveilan, where a noble façade of columnar trap descends perpendicularly and without a break into the sea, rising to an elevation, as I should guess, of 200 feet. In picturesque effect, and in continuous profundity of shade, it excels even the celebrated cliffs of Staffa. The columns are however neither so regular nor so perpendicular as those of that island, but rather resemble the obscurely formed ones which occur on the shores of Ulva. A few here and there present nearly the same degree of regularity as those well-known specimens on the south side of Arthur's seat. This colonnade extends along a great part of the northern shore, plunging under the water to the eastward, while towards the west it is so elevated as to allow an examination of several strata, which lie beneath it. At the south side of the island the ground slopes so as nearly to meet the sea. It is on this south side, and at the eastern end, that these different strata come into view. The lowermost bed is a dark purple hornstone, of which the thickness cannot be determined, as nothing is seen below it. The accompanying specimens will preclude the necessity of describing a rock of no uncommon occurrence, whether the name by which I have designated it be one about which mineralogists are agreed, or not. It has unfortunately been applied to so many different stones, that it is utterly impossible to steer clear of difficulties. Among the reforms of nomenclature, in the departments of rocks, the term hornstone, and the various substances which have been classed under it, call loudly for examination. The adoption of petrosilex might have gone some way to remove this confusion, as we should then have had two names instead of one, by which to designate four or five different substances; but as this latter appellation has been equally misapplied with the former, and different authors have called the same substance by both these names, the confusion has, if any thing, been increased. Mineralogists may inquire whether by a due appropriation and limitation of the three terms, hornstone, chert, and petrosilex, already in use, some progress may not be made in removing this obscurity without any material additions to our nomenclature. I forbear even to hint at the apparently, and only apparently, corresponding French terms, pierre de corne, and cornéene, lest I should drive the reformer to despair.

But to return. This bed dips to the south-west, and appears to have about 15 degrees of elevation. Immediately above it lies a bed of rock, about 20 feet in thickness, and of a structure so peculiar as to require a more detailed description.

It is formed of globules, every where adhering together, not merely by their touching surfaces, like most of the pisolites, but in general by large segments, similar to the globular limestone of Sunderland. These are occasionally compressed as if by a superincumbent weight, but in many places are absolutely spherical, and by their accumulation become botryoidal, smaller spheres growing out as it were from the larger ones. Detached specimens that have been washed by the sea, exhibit the appearance of a bunch of grapes, but in their native bed the intervals are filled with an ochry clay. Their fracture shows the uniform aspect of siliceous schist, being neither coated nor radiated; and the rock agrees in every respect, except its structure, with the bed of siliceous schist, which is found not far off.

I have only observed one other instance of a rock similar to this, and it occurs also under amygdaloidal trap at Talisker, in Sky.* I have reason to suppose it of rare occurrence. In various parts of the rocks which I have now described there are found natural joints, which on being separated exhibit two smooth surfaces, absolutely flat, and appearing as if they had been cut through by a sharp tool. The globular bodies themselves are divided in various parts, just as they happened to interfere with the section. In the greater number of the sections which I examined, no substance was interposed between the touching faces. But in some I found wavellite, a mineral as yet not so common, but that this new *habitat* will be acceptable to the mineralogist. It is remarkable that the circles of wavellite occupy precisely the surface of each segment of the several spheres, varying in size according to the varying dimensions of these segments. This bed is covered by one of trap, or to use the term in its present great latitude, of greenstone, forming a parallel bed of a more considerable thickness, but with the same inclination as the subjacent strata. This bed of greenstone weathers so as to exhibit distinct globular concretions, although in its entire state the eye can

* I have since observed a similar modification in the schist of Devonshire in which wavellite is found.

trace no difference between the amorphous portion and the columnar mass which forms the upper part of the island. This very common fact should serve to convince us how little information we can obtain of the true and fundamental structure of rocks, from their natural fracture, while in a state of integrity.

The bed of trap which I have now described, is followed by a bed of schistus, which may be called a siliceous schistus, a term likewise under which many substances have been very improperly confounded, although the characters of this rock are sufficiently defined to render such carelessness of description inexcusable.

But it is not only in mineralogy that the desire of accounting for that of which the cause is unknown, and of describing that which is not understood, predominates over those severer habits of investigation, which can alone render scientific description accurate.

It is too hopeless a task to attempt to develope the confusion of rocks to which the terms cornèene and trap have been applied, names which will probably be given to this rock by those who follow the French nomenclature. I believe I go along with Mr. Jameson, in calling it flinty slate, or siliceous schist, and it will perhaps be considered a variety of that which is called Lydian stone. It breaks naturally into prismatic and rhomboidal fragments, but its forcible fracture is flat, approaching to the conchoidal, with a small degree of lustre, and without grain. It is exceedingly brittle, and cuts the hands like glass. Its gives fire readily with steel, and the file scarcely touches it. Its colour is a dark lead grey.

Natural joints, similar to those I noticed in the botryoidal schistus, (if I may venture thus to distinguish the rock described above) occur also in this schistus, and circular stains may be observed upon the planes of contact. I did not find any specimen of wavellite in this variety; but I cannot pass on without remarking that the habits of this rock, and its connections, in all the cases where I have had an opportunity of seeing it, seem to point it out as an argillaceous schist, altered and indurated in consequence of its proximity to greenstone.

The last bed is the immense mass of columnar trap already mentioned, which surmounts the whole. The character of this rock is not that of a greenstone, to use the word in its more restrained sense, as it does not contain distinct grains of hornblende and felspar, but is an obscure mixture of hornblende, felspar, and quartz.

I have therefore both here and in other places, (where I have had occasion to describe the varieties of this rock, of which the characters are not so decided as to admit of their being placed either under the heads of basalt, wacke, or greenstone,) preferred the general name of trap to the use of a specific one with which the characters of the individual cannot be made to agree. In so doing I have left out of view the confusion which must arise if the siliceous schist, and Lydian stone, which appear to be the trap of some authors, be considered as forming a part of this great natural division, and have taken the term, as I imagine, in the sense intended by the followers of Werner. It is thus used by them as the title of a *family*, including basalt, wacke, greenstone, and clinkstone, a family well expressed by the vernacular term *whin*, now, I believe, and perhaps unfortunately, obsolete. The characters of basalt, wacke, greenstone, and clinkstone, are tolerably decided, and the geological relations of the trap family are so remarkable that we ought to find little difficulty in assigning proper terms of distinction to its respective members. But, independently of these four well characterized rocks, innumerable varieties occur not properly referable to either, and which cannot even be truly expressed without much circumlocution, and reference to those well-known members which they may chance to resemble. If in these cases we apply the name of any of their species in place of a generic term, we render our description of individuals unintelligible, and often contradictory and absurd. Thus the name basalt has been given to greenstone, as well as to many other modifications of trap, to which no name has, or perhaps ever can be applied. But the chief confusion has resulted from the application of the term greenstone, as a generic term for these rocks. In this way we have had greenstones of all colours, from red to white, and in which neither hornblende nor felspar were to be distinguished.

It would assuredly be better in describing the geological appearances of these rocks, when the description of individuals is not necessary, to make use of a generic term which should distinguish the character of the family, without confounding the individuals. The peculiar aspect of the rocks of this family renders the name of trap as expressive as any which can be applied, and in this sense, if it be limited to that well-known class of unstratified rocks which includes the above-named individuals and their numerous modifications, we shall escape the confusion which must otherwise ensue, and which unfortunately already exists too much.

It is evident that the other modifications of this rock consisting of amygdaloid and of the various trap porphyries, are still further subordinate species, if I may style them so, ranking according to their particular basis, under the several species above enumerated.

It is said that in the Shiant islands ammonites and other animal remains are discovered in beds under the trap, but I did not observe them. They may very probably however exist here, as they are of frequent occurrence in Sky.

Among the rolled pebbles on the shore I met with specimens of pink coloured quartz. I did not observe any foreign matters imbedded in the trap, except minute drusy veins of calcareous spar.

Such are the very limited observations, which an inspection unavoidably much hurried, enabled me to make on this part of the group. Although the general aspect of the other two islands would lead me to expect in them an identity of structure, yet they may afford differences worthy of further investigation.

Rum.

A stormy sea, a dangerous shore, want of harbours, a trackless country, and a scanty and wretched population, render it as difficult a task to reach this island as to examine it.

It forms one mountainous tract of rugged and barren aspect, and of considerable extent, although its highest mountains, which lie towards the west, do not appear to exceed two thousand feet in elevation. My observations were limited to the only two parts of the island which are tolerably practicable, Loch Skresort, and Scuirmore.

Loch Skresort forms a semicircular indented bay, from which the land shelves gradually upwards by a moderate acclivity, till it approaches the middle region of the mountains, from whence the further ascent is steep, rugged, and often precipitous to the very summits. These terminate in craggy and broken points, exhibiting abrupt faces, and piles of ruins. The rock which incloses the bay of Loch Skresort, is a reddish argillaceous sandstone, disposed in beds and elevated to a low angle, varying from ten to fifteen degrees, occasionally fractured, bent, and displaced. It appears to be the result of the decomposition of granite, since the argillaceous grains are often found to consist of felspar in a state of integrity, although at times putting on the appearance of clay. The quartz is of a brownish red colour. My examination of it was by no means sufficiently extensive to enable me to say what varieties may exist in different places, but it has an aspect and disposition so perfectly analogous to that of the sandstone which lies under the Cuchullin mountain on the opposite shore of Sky, and which forms the greater part of the island of Soa Vretil, that I consider them as belonging to one bed. As I shall have occasion to describe this rock again in the remarks which I propose to offer on Sky, I forbear to dwell on it here. The basalt veins, so common throughout all the islands of this coast, traverse this sandstone, but are not so abundant immediately about Loch Skresort, as is common on these shores. Where the sandstone terminates on ascending towards the mountain, it is succeeded by a mass of rock, which bears the general aspect and features of the mountain trap rocks, of the rocks for example which constitute the Cuchullin mountains, and which are perfectly distinguished in their general characters from those which, on account of their bedded and parallel appearance, are well designated by the term *floetz* trap.

But the composition of this rock is peculiar, and, as far as I know, resembles no other in Scotland. It consists of two ingredients only, and has at first sight the aspect of those syenitic traps so common in the Cuchullin, which are formed of hornblende and felspar, in large crystals: but instead of hornblende it contains augite. These substances, the felspar and augite, are confusedly crystallized together; and although the concretions vary much in size, they are most generally large, and appear to increase in dimensions on approaching nearer to the summit of the mountain. The crystals of augite are not unfrequently an inch or more in length. Although I traversed a considerable space over these mountains, I did not discover any variation from this general character. I should add, that the felspar is the glassy variety.

The cliffs from Loch Skresort to Scuir-more, exhibit the same general appearances of sandstone skirting the shores, and intersected by trap veins, or with masses of trap rocks superimposed on them. A more particular knowledge of this coast is scarcely attainable either from sea or land. At Scuir-more a small beach affords a point of access, and here some variations occur which are worthy of notice.

The sandstone is in this place elevated at very high angles, varying from forty to sixty degrees and upward, and it appears to dip uniformly toward the west. In composition it differs more materially, being ferruginous from oxide of iron, and in place of clay, containing calcareous earth. It is also traversed by numerous minute veins of calcareous spar, and is intersected by innumerable basaltic veins, of different sizes, and often of great magnitude. By these and the subsequent disintegration of the rocks, it is hollowed into caves, and wrought into arches, producing strange and picturesque scenes of ruinous grandeur. I may remark, that the junction of these different rocks does not appear to be attended with any change in the nature of either. In one of the veins there is a portion containing a compound of an uncommon nature, but somewhat resembling the rock above described, being a mixed mass of crystals of augite, hornblende, and felspar. Loose specimens of black pitch-stone are also found on the beach, arising in all probability from some vein of that substance. But the production for which it is most remarkable is the green chalcedony, or heliotrope as it is generally called.

This substance, which exists in large masses, is also found occupying cavities in the basaltic amygdaloid, in nodules varying from the size of a mustard seed to that of a pea. These are accompanied by similar nodules of calcareous spar, often also penetrated by green earth (chlorite baldogée.) This amygdaloid accompanies the larger masses of green chalcedony, and seldom extends many inches beyond them. The great masses are either in the form of irregular nodules, reaching from the size of an egg to that of a man's head, or they resemble short veins, of which the opposing sides are flat, and somewhat parallel, and which might perhaps more properly be called angular nodules. Their colour is as various as their other external characters, but the most frequent varieties are comprehended in the following list.

1. White chalcedony? approaching to quartz, and sometimes to hornstone, in its aspect, fracture, and other qualities.

2. Pure chalcedony of a more or less milky hue, constituting the chalcedony and the white carnelian of lapidaries.

3. The first variety of chalcedony, of a brown colour with narrow parallel stripes of green.

4. The same, irregularly mottled with green, white, and brown.

5. The opaque, or first variety of chalcedony, of an uniform dark sap green, with the dull fracture and aspect of wax, and like that substance, translucent on the thin edges.

6. The translucent variety, similarly coloured, but with a more conchoidal fracture, and of a glassy aspect.

7. Varieties which in one specimen exhibit a perfect gradation from pure white or colourless chalcedony, to the deepest green.

All these varieties contain imbedded spherical bodies, varying from the size of the minutest poppy seed, to that of a mustard seed. These are frequently formed of pyrites, and although they are often entirely decomposed, yet they now and then exhibit the remains of a crystal of pyrites within them, and their external surfaces retain a ridgy and crystallized aspect, the remains of the edges of the plates which have formed them. But the most common of the spherical bodies are, when fresh broken, of a white colour, becoming at first yellow by exposure to air, and subsequently of a dark brown. Their internal texture, as far as it can be determined by high magnifying powers, appears platy, and although it is difficult to speak with certainty of bodies so minute, and so much out of the reach of examination, they seem greatly to resemble brown spar; a conclusion rendered more probable, by the changes which they undergo on exposure to the air. The whole of these chalcedonies are occasionally penetrated by laminæ of calcareous spar, which are often so numerous as to form nearly one half of the stone, and which from its yielding in their direction, rather than in that of the chalcedony, do often seem on a superficial view to form the whole of it. In the rifts of these chalcedonies, we may occasionally find detached masses of green earth, which by its combination with the stone itself appears beyond all doubt to be the colouring ingredient. Its unequal diffusion through the stone, is equally demonstrative of the same supposition.

We have now to compare the green chalcedony of Rum, with the stone known by the name of heliotrope, and commonly called *oriental*, since that name has been applied to it, and as it will appear, with perfect propriety. The fracture and translucency of the true *oriental* heliotrope, show, as Brongniart has well remarked, that it has been improperly ranked among the jaspers; and the description and natural analysis, if I may so call it, which I have now given of the stone of Rum, confirm the propriety of his remark, and refer it to its true place among the varieties of chalcedony. It is true, that the stone of Rum very rarely exhibits the red spots which so often occur in the *oriental* kinds, but these are purely accidental. An examination of many specimens of the latter in my possession, has proved the existence in it of variations in regard to lustre, and other characters, precisely similar to those I have noticed in the stone of Rum. In these too, the fracture is now and then waxy, flat, and dull; occasionally it is conchoidal, shining, and highly translucent, but it never approaches to the earthy aspect of true jasper. The irregular diffusion of the green earth is also equally remarkable in some of the *oriental* specimens, since among those which have fallen under my examination the green colour is often diffused in partial stains through a pure chalcedony, so that the distinct grains of green earth are discernible by the lens. These also being accompanied by the blood marks esteemed characteristic of this stone, leave the determination of its name free of doubt.

We may therefore conclude, that the green stone of Rum is the true heliotrope of lapidaries, and that this stone is merely a mixture of green earth with chalcedony, its external characters varying either from the variations in the quality of its base, or from the quantity of the green matter with which it is combined.

I did not perceive among the green chalcedonies of Rum any specimen resembling the plasma of the Italians, unless perhaps that in some of them small parts of a more remarkable transparency might occasionally be traced. Yet, as among specimens of the real plasma which I received from Egypt, there are green spots in the stone, resembling minute crystals of chlorite, independent of the general green stain which pervades the whole, I think it not unlikely that this substance is also the colouring matter of plasma, and that the only difference between that mineral and heliotrope, will be found to consist in the different transparency of the siliceous stone which receives the colour. It is not therefore improbable but that plasma as well as heliotrope may be an inmate of the trap rocks of Scuir-more.

A substance is occasionally brought from India, known to lapidaries by the name of brown carnelian, and it is esteemed peculiarly rare. This substance also is found among the chalcedonies of Rum, occupying the same situation as the green varieties, and differing from them only in colour. It probably owes its stain to iron. Motley mixtures of brown, and green, of considerable beauty, add to the variety of ornamental stones which these rocks contain.

The apparently inaccessible nature of the southern shore of Rum, prevented me from extending further my observations on this interesting island. But in coasting it slowly along, it offered the same general appearance as the cliffs I have now been describing which look toward the island of Canna, exhibiting one formidable wall of basaltic aspect, reposing on a base of sandstone. It will be for more successful geologists to examine whether circumstances equally interesting, and of a different nature, may not be found among the caverns and ruins of this repulsive, if not absolutely inaccessible coast.

Egg.

I have little to add to the description of Egg given in the "Mineralogy of the Scottish isles," but the following fact relating to the situation of the promontory called the Scuir of Egg, which is not noticed in that work. The columns which form this most magnificent precipice, exceeding in grandeur and picturesque effect even the far famed Staffa, are of a black pitchstone porphyry. They are disposed in various perpendicular, inclined, and horizontal directions, and are either straight, or curved, but never jointed. The felspar which they contain is the glassy variety. The lines which separate the different sets of columns, together with the varying inclinations of these beds, seem to mark different sets of deposits. The whole promontory lies on a bed of compact grey limestone, generally indeed approaching to the character of a stone marle. This bed is three or four feet thick, and rests on a still lower bed of hard reddish sandstone, beneath which nothing is visible. Large masses of wood, bituminized and penetrated with carbonat of lime, are found in the marle stratum, not at all flattened. Portions also of trunks of trees retaining their original shape, are seen in the same bed, silicified, and their rifts filled with chalcedony, approaching in aspect to semi-opal.

Assynt.

I have separated the account of the limestone which accompanies the quartz rock of Assynt hereafter to be described, and which forms so conspicuous a range of hills, because its connection with that rock is tolerably obvious, and throws no light on its history. But its peculiarity of character, and the great space which it occupies, render it highly deserving of notice, as I believe Scotland no where affords a tract of limestone so extensive.

A low chain of hills commences about Achamore, and accompanies the Tain road towards the east for four or five miles, lying as it were in a large valley bounded on both sides by an interrupted range of quartz mountains. It appears to rise gradually as it extends eastward, and about the Kirk of Assynt attains a height of 1200 or 1400 feet, forming a large and magnificent continuous mountain ridge, exhibiting a great mural face of precipitous rock to the south, and shelving away to the northward. The dip and direction of the quartz mountains appear in this place to be similar to those of the limestone. The uppermost part of this ridge seems to consist of one great uninterrupted bed of limestone, some hundreds of feet in thickness, or rather, of an accumulation of beds; well marked horizontal lines being observed to extend in a parallel direction along the precipice. It is also completely traversed by perpendicular fissures.

Below this great mass a bed of quartz or sandstone, of considerable thickness, is to be seen running parallel with, and separating the incumbent from a similar subjacent body of limestone. I did not observe whether this alternation is carried further, but it is probable that it might be discovered in some other parts of the ridge. The limited extent of my investigation also prevented me from determining the position of the limestone relative to the great sandstone or quartz formation; whether it lies upon the sandstone which rises to the south of it, and under that which rises to the north, or whether it is a partial deposit, occupying the valley alone, and incumbent on the whole mass. The examination of an extensive tract of very difficult access, would be requisite to decide this question, as well as to ascertain the magnitude of its extent, and the nature of the limits by which it is bounded. Yet, the appearance of a quartz bed alternating with it, renders it probable that it is also interposed among some of the larger masses. The beds which I have described are elevated to a considerable angle, and although in some places their section forms a continuous and even line, in others they are curved and broken, and tossed about to such a degree, that their stratified position can scarcely be perceived. The stone itself is a dark grey or nearly black bituminous limestone, of an earthy aspect, and minute granular fracture, smelling offensively when rubbed. I did not any where observe animal remains in it. In many places it is fissured into small fragments, the intervals of which having been subsequently filled up by red or white sparry matter, a beautiful variety of marble is produced, which is now wrought for the purposes of ornament. Its cavities also occasionally contain large and perfect crystals of that form of calcareous spar called *equiaxe*. Its surface is in most parts covered with a loose calcareous tufo, which in some places being solidified by an infiltration of calcareous matter, forms beds of solid breccia. It contains grains of sand dispersed throughout, and for this reason, commonly gives fire with steel, a circumstance of very frequent occurrence in all stratified limestones, whether referred to the rocks called *flœtz*, or *transition*, and generally most conspicuous in those which contain animal remains in abundance. Such are the circumstances of chief importance in the character and position of this limestone.

I shall now, perhaps, be expected to assign a place to this rock in the usual division of *primary*, *transition*, and *flœtz*, distinctions which I am inclined to think are more easily made in the closet than in the field. In the present state of geological science, it would appear a safer practice in this case, as in many others, to describe that which actually exists, without the use of hypothetical terms, which only serve to perplex the observer, and to mislead the student, who either boldly pronounces on the character which suits his particular creed, or modestly supposes himself incapable of sound observation, because he is unable to see that which is not visible. If the quartz rock of this tract be a primitive rock, then the limestone is necessarily a primitive rock also, notwithstanding its bituminous nature, and accurately stratified structure, since it alternates with it. But, if this rock is not a primitive, but a transition rock, then the limestone also must be removed from the first class of rocks to the second.

In examining its right to a place among the transition rocks, we must compare its characters with those which have been assigned as the essential distinction of those rocks. I read in the exposition of the Wernerian system best known to us, that " transition limestone contains petrifactions of marine animals," and " that it rests immediately on newer clay slate," and in the numerous distinctions assembled for the purpose of defining it, these are the only two which appear capable of being rendered truly definitive. Certainly neither of those characters is found in this limestone. Equal difficulties oppose its admission among the *flœtz* rocks, when we consider its connection with the quartz rock, which, whatever division it may be referred to of the older formations, can scarcely be supposed to belong to this class. Having no anxiety on this head, and conceiving that we are still deficient in information, both on the nature of this district, and on the subject at large, I shall willingly leave the determination of its artificial place to those who are either better acquainted with the unwritten laws by which these matters are regulated, or to a period of further information.

To a mere observer, uninfluenced by systems, it exhibits the remains of a disposition originally stratified and horizontal, but disturbed, inclined, and broken, by subsequent changes;—a disposition, which however uniform in more distant times, has been altered to its present one with a partial, not a total loss of its original character, by revolutions of which the antiquity and magnitude are unknown to us, and by agencies which we are ill able to explain. Any system of arrangement may be useful, which, although artificial, assists us in classing and describing phenomena more satisfactorily; but if we are to adopt the system of arrangement to which I have alluded above, it is much to be desired that geologists would furnish us with such characters as shall enable us to decide on the different bodies appertaining to the several divisions of their system, without which, an artificial arrangement is not merely nugatory, but injurious to correct observation, chaining down our conclusions in an obedience to particular dogmas, and producing impediments destructive to the progress of legitimate science.

Another tract of limestone, of a distinct character, occurs in the same valley, occupying a position nearly parallel, at some distance from it. Of this I have unfortunately nothing to record beyond the detail of specimens. The whole inclination of the hill on this side of the valley is covered with a deep bed of soil, such as to render it impossible to trace the position of the rock, of which, all that is visible appears in the form of detached masses, apparently without order or semblance of stratification, rising through the grass.

The rock itself is an object worthy of attention from its œconomical qualities, affording various specimens of marble, of a colour from pure white to grey, which have already been introduced into commerce, and for which a premium has been assigned to Mr. Joplin, of Gateshead, from the Society of Arts. It is the same marble described by Williams. The principal varieties are the following:

1. Pure white of a milky opaque aspect, with a crystalline texture, and large grained granular fracture, approaching to the splintery. Acquires a smooth surface on the polisher, but remains of a dead hue like the marble of Iona, reflecting no light. Hence its uses as an ornamental marble are much circumscribed.

2. White mottled with gray, of a large platy fracture, and capable of receiving a high polish, forming a marble of some beauty.

3. Highly crystalline and translucent, with a large platy fracture, and of a gray colour, capable of being applied to the purposes of ornament in sepulchral sculpture.

4. Of an uniform dove colour, very compact and translucent, assuming an excellent polish.

5. Pure white, of a large platy fracture, and translucent appearance, capable of being used in plain ornaments, but too transparent for sculpture.

6. White, with irregular yellow stains, from serpentine intermixed; extremely fine, compact, and fine grained splintery.

7. Intersected by thin laminæ of schiefer spar, of an exceedingly splendent appearance.

Isla.

My object in laying before the Society the series of specimens collected in Isla, is the correction of some mistakes which have been entertained about the nature of its limestone district; a district of some importance in more than a speculative view, as it forms a mining field in which lead ores have been wrought to a considerable extent. My researches in Isla having been limited to this particular part of it, I shall confine myself to that which I have seen, referring to Mr. Jameson's book for such further information as may be found in it. I may, however, venture to point out this island as a spot in which the very important circumstance alluded to in another place, of the connection of the quartz rock with the mica slate, and clay slate, might be studied to great advantage. This deduction is not drawn from my own observations, which were not sufficiently numerous to enable me to decide on a question so important, but from the narrative of Mr. Jameson, who appears to describe frequent alternations of those different classes of rocks. Extensive and correct observations on Isla, would probably determine the true relative æra of the quartz rock, and elucidate still further the disposition of Schihallien, of Jura, and of the north of Scotland. I shall merely indulge in a few very cursory remarks on this part of the formation of Isla.

I have stated in another place that in Jura the quartz rock assumes towards the shores a disposition far less regular than that which it exhibits in the elevated districts. On the sides of the narrow strait which separates this island from Isla, this irregularity is particularly remarkable, and it is also very easy of access. These rocks possess all the varieties of structure which I have formerly described, and with them mica slate and clay slate are found in beds, which, even if this question had not already been decided by evidence drawn from other places, I should have no hesitation in calling alternate.

The shores of Isla which form the other side of this narrow strait, resemble those of Jura so perfectly, and correspond with them so nicely in their various characters, that a spectator would not, without a geographical mark for his guide, be able to determine which of the two he was examining. We may, without hazarding too strong a conjecture, look back to a time when these islands formed one continuous tract. Veins of basalt and granite are to be observed in both, the former by their superior permanence bearing a resemblance to high walls, which at a distance emulate ancient ruins; appearances similar to that which forms the supposed volcanic amphitheatre of Mull, so highly pictured by Faujas de St. Fond. Some varieties of this basalt exhibit by an incipient decomposition, a structure consisting of thin lamellæ, and occurring, although in a less remarkable degree, at the Giant's Causeway. There is an example of this structure among the specimens which are the subject of the present brief commentary.

But to proceed to the great limestone district of Isla. Mr. Necker's map in the possession of the Society, founded on the general opinion of the mineralogists of Scotland, calls it a flœtz limestone.

A very cursory survey of it is sufficient to show, that it consists of irregular and broken fragments of beds disposed in every possible position. Occasionally it is flat, but is now and then elevated at a small angle, and often appears as if it consisted of strata perfectly vertical. Almost every where it is disturbed and contorted to a great degree. The beds are easily traced in several places, where quarries have been dug, or mines wrought; and in many others the inclination of the soil and the action of water, have laid the edges bare for some hundreds of yards together. The perfect similarity of its disposition to that of the limestone which accompanies clay slate all over the Highlands of Scotland, and more particularly to that of the island of Lismore, would suffice to determine its true character, even without the detail of specimens. There are two predominant varieties of it. Of these, one is dark blue, and the other greyish white. They are both compact, and hard, but the aspect of the whiter varieties is more crystalline than that of the dark, which indeed often possess a merely earthy and granular appearance. In many places the blue varieties, where most crystalline, are traversed by numerous veins of a white colour, producing an ornamental marble worthy of attention.

The blue varieties of this limestone appear to be deposited in contact with clay slate, the white on the contrary, which are much more rare, are found in contact with a micaceous slate.

When the blue variety approaches the clay slate, it first assumes a schistose fracture. Shortly after it appears penetrated with delicate laminæ of straight or undulating silky schistus, which by degrees increase in number, and at length so predominate, that it is only by examining the cross fracture, and even with some care, that the presence of limestone is discovered in the mass. Ultimately the limestone disappears from the schistus.

The whiter varieties, which I have described as more rare, are found in contact with a micaceous schistus consisting of thick flexuous laminæ of quartz separated by thin layers of mica. Here the gradation from the limestone to the micaceous slate takes place, by an alternation of the layers of mica with the limestone, forming a rock easily mistaken for mica slate, and resembling the Cipolino marble of the Italians. These limestones are no where bituminous, and it is scarcely necessary to say, that I did not observe in them any animal remains. A breccia formed of both the varieties is found here and there, and I observed detached specimens of a variety filled with minute pores, which although it exhibits no decided animal appearances, has yet a suspicious character. A specimen is before the Society for the examination of those who possess superior experience in these modifications.

It now remains to determine the place of this limestone in the system of Werner: a determination which probably involves the character of all the limestones so frequent in the Highlands of Scotland, which, like this, are deposited with schistus. The instances which occur at Balahulish, at Loch Earn, at Lismore, at Dun MacSniochain, and at numerous other places, are too familiar to be pointed out to those who are acquainted with Scottish mineralogy.

It is evident that the character of the limestone must, in this case, depend on that of the rocks which it accompanies, and not on the mixture of mica or other foreign minerals which it may contain. If the clay slate and mica slate of Isla are both considered primitive, as they probably will be, then this limestone must also be ranked among the primitive rocks. In all the other instances in which I have observed this kind of limestone, it has appeared to me to appertain to the same system of rocks. Yet I have reason to suppose that the beds of it which exist in the district of Aberfoyle, alternate with a sort of intermediate rock, which I am inclined to consider as the latest of the primitive, or the oldest of the transition series, a rock approaching at least as near to the character of graywacke, as to that of micaceous schist, if it be possible, as I suspect it is not, to draw any line between these two classes of rocks. In this case, the same limestone will, like clay slate, bear a share in both these artificial divisions, for artificial I must needs consider divisions which nature has separated by a boundary so feeble and so undefinable.

Ailsa.

The craig of Ailsa, from which the specimens now exhibited are taken, resembles the summit of a huge mountain rising abruptly out of the deep. Such in fact it is, and not a mere rock, as its name might induce one to suppose. It shelves rapidly into the sea, and is surrounded by deep water on all sides except the south eastern, where a small beach has been formed by the accumulation of its ruins. I regret that the derangement of my barometer, a derangement unfortunately too frequent, prevented me from ascertaining its altitude; but by comparing its appearance with that of Arthur's seat, and computing from the time it required to ascend it, it cannot be much less than 1000 feet in height. It is called 940 in some of the sea charts, but on what authority I do not know.

Its circumference cannot be less than two miles, and it therefore forms a large island, which is covered with verdure, and is the habitation of gulls, awks, gannets, goats and rabbits. Its shape is round and cumbrous when viewed from the north-west, but when seen from the north it assumes an elegant conical figure.

It is bounded on the north-west by perpendicular cliffs, 200 or 300 feet in height, but on the other sides it declines by a rapid grassy slope to the sea, intermixed however with rocky faces, and covered with heaps of fragments, which are perpetually falling from the bare rock. The square ruined tower which remains at about a third part of its elevation, offers nothing interesting to the antiquary, but the botanist will be delighted with the profusion of lychnis dioica and silene amæna which covers it with a dense coat of flowers; to the exclusion of even the grass. It contains springs at about 200 feet below its summit, which unite in a small marshy plain, covered with enormous plants of hydrocotyle vulgaris.

The rock which forms this insular mountain is in general amorphous, and breaks into large irregular masses, sometimes approaching to a rectangular shape, sometimes without that tendency, and resembling the fragments of quartz rock. In many places it approaches to an obscure columnar structure, and this occasionally acquires great regularity. It is on the north-west side that the columns are most perfect. They are here well defined in their angles, yet adhere together, so as to appear to form one continuous mass, their true structure being only detected by the occasional falling of the huge fragments which strew the narrow beach on this quarter of the island. They vary in the number of their sides, but like basaltic columns, the most general forms are the pentagonal and hexagonal. I could not any where perceive that they were jointed, but they break at right angles to their axes, forming those flat summits which are tenanted by clouds of gannets. Their dimensions are universally large, as they are from six to eight feet in diameter, and extend in height as far as the eye can judge, to a continuous altitude of 100 feet and upwards. Nothing can exceed the magnificence of the columnar wall on this side of the rock; even the high faces of Staffa sink into insignificance on a comparison with the enormous elevation and dimensions of Ailsa. With that elevation is combined an air of grandeur, arising from the simplicity of their aspect, which the pencil and pen are equally incapable of describing. To the lover of picturesque beauty, they possess a requisite, of which the want is perpetually felt in contemplating the basaltic columns of Staffa, or Egg. This is their gray colour, catching the most varied lights and reflections, when the iron cliffs of basalt are confounded in one indiscriminate gloom. He is an incurious geologist, or a feeble admirer of fine nature, who is content to pass Ailsa unseen.

This rock is traversed in various parts by large veins of greenstone or basalt. Among these I observed one which was horizontal, but the greater number are vertical, and of large dimensions: these lie on the west side. There is no apparent alteration in the rock at the points of contact. The whole of this island consists of one substance, in which slight differences of appearance here and there occur, but are unworthy of particular notice, and scarcely sufficient to constitute a variety. Its basis is an even and small grained mixture of white felspar, and transparent quartz, in which the former appears to predominate. This mixture constitutes more than three-fourths of the stone, and is mottled by minute and indistinct stains of a black colour, which through the magnifying glass are seen to consist of small grains of hornblende. These appear as if diluted through the stone, and arising from a common centre; and as they vary in proportion to the other constituents, so the rock assumes various shades of colour, from a whitish to a blackish gray, but the lighter varieties predominate.

The stone which I have described may safely be called a syenite, as it accords with Werner's definition of that compound rock, and is a term pretty generally admitted. We may, however, venture to question the propriety of applying to rocks of this nature, a term borrowed from the ancient naturalists, when it seems certain that the rock of Syene was, in fact, a true granite, containing hornblende merely as an occasional and accidental ingredient. Yet, as we are in want of a generic term for the various rocks which consist of hornblende and felspar, and which are not considered as greenstones, it may be advisable to admit of its use for this purpose, and to sacrifice a little of our classical accuracy for the sake of convenience, rather than by the introduction of another new term, to introduce new confusion into that which already reigns in the denominations of rocks. I hold it necessary however that the word syenite, if it is to be used as a generic term, should be limited, as rigidly as the ever varying and mingling composition of rocks will admit, to those compound rocks which are akin to greenstone in their chemical and essential characters, or consist of certain notable and distinct proportions of felspar and hornblende, but in which the felspar is either the predominating ingredient, or is crystallized in masses so large and distinct as to remove the compound from those similar compositions now generally known by the name of greenstone. When the condition of the stone is of that intermediate nature which renders its precise place uncertain, the modified term of syenitic greenstone is easily applied. In difficult cases where these rocks are still more varied in their composition, and in all others where a multiplication of terms would lead to an unbounded and unnecessary nomenclature, it will even be preferable to distinguish the variation from the more rigid form by a detailed description rather than to encumber the science with a useless neology. It is easily understood that no doubts respecting the place of these rocks in a system, need arise from the intermixture of quartz, or even of mica in the stone, provided their proportions are not conspicuous, nor their influence on its general aspect remarkable.

But the rocks themselves, to which I am thus desirous of limiting the name of syenite, are so associated in their habits and formation with the rocks of the trap family, and with those porphyries which appear to have originated in similar circumstances, that they have a strong claim on us for one generic term, as well from their geological, as their chemical, or mineralogical relations. If then we consider the term syenite as founded on this double view of the nature and position of the rocks to which I allude, it will be obviously convenient, if not absolutely necessary, to separate from them the rocks of a granitic character; of these the most simple in its construction is that which consists of quartz, felspar, and hornblende, or of those three ingredients with mica. Such rocks are not of uncommon occurrence, nor is it uncommon to meet a rock in which quartz, felspar and mica are so compounded, as to form a true granite with crystals of hornblende superadded to the compound. Great confusion must follow the separation of these from the granites, and their union to the syenites above described. Their structure and characters are in all cases granitic, nor does the eye readily detect the difference till the darker parts are minutely examined, when the crystals of hornblende may, and that often only with much care, be distinguished from the mica. Their geological affinities associate them also with the granites, and never with the greenstones, since they occur in the *formations* of the granite æra, as hornblende rock and hornblende slate are known to do. The obvious distinction would be to call these compounds syenitic granites, thus preserving their analogy with the syenitic greenstones, and preventing us from confounding into one mass two formations of widely different characters and epochas, merely from the accidental presence of a single ingredient.

But to return to our subject. We have here an example of the columnar form existing in a very perfect manner in a rock, which however it may bear a considerable analogy to greenstone, and through that to those rocks which more commonly exhibit the columnar shape, is still sufficiently distinguished from them all by the great predominance of the felspar. There is no difficulty in conceiving that the same causes presided at the formation of both, when we consider the similarity of geological structure and position which pervades all the rocks distributed under the heads of basalt, greenstone, and syenite.

The insulated position of this rock precludes all possibility of tracing its connection with the contiguous ones, and the chasm which exists between Ailsa and the neighbouring shores, is such as to insulate it as much in a geological view, as it is in its geographical position.

As yet nothing resembling it in structure has been observed in the neighbouring islands, nor on the main land of Scotland, yet the syenites and greenstones of the motley island of Arran, with the porphyry of Devar, and the extensive trap formation of the neighbouring shores, point out to us its natural affinities, and enable us to guess at a connection possibly once more intimate, but long since submerged in the depths of the sea.

I cannot entirely quit the Craig of Ailsa, without remarking that it possesses in a high degree one of the conditions requisite to the solution of the interesting problem of the earth's density. This is, the absolute uniformity of its structure, which, with the exception of the few basaltic veins above described, is of one unvarying rock. Its mass is also sufficiently considerable to fulfil another of the conditions required for this problem, while its form and situation would appear to afford sufficient facilities for measuring its solid contents.

As this idea had not suggested itself to me when on the rock, I did not examine, and cannot now recollect, whether it affords situations adapted for the erection of the requisite observatories, a condition without which its other conveniences would be of no avail.

Devar.

The beautiful specimens of porphyry taken from this rock may render a short description of the rock itself interesting, and I shall therefore make no apology for occupying the Society a few minutes with an account of it. It is the more worthy of notice, as it is the most accessible, and the best characterized mass of porphyry which I have seen in the various parts of Scotland that I have visited. It is an island and a peninsula alternately, according to the state of the tides, and lies off the harbour of Campbelltown, which it covers from the south and east winds. It is about half a mile in length, and a quarter in breadth. From the N.W. it rises in a pretty rapid slope, and terminates to the S.E. in a precipitous face, reaching as far as the eye can guess, from one to four hundred feet. It consists of one entire mass of porphyry, which however varies much in its colour and texture in different places. It contains no other rock or vein, nor is its contact or connection with any other to be traced, but it appears to extend on all sides below the water. On a first and cursory view, it seems to be formed of upright beds, but a more accurate examination shows that this appearance is a deception, and arises from the tendency which the rock has to split in a vertical direction. Such is its outline and general aspect that it might at a distance be taken for a mass of trap, similar to those in the vicinity of Edinburgh, its leading features being the abrupt face and perpendicular fracture. On examining this great fracture more closely we may perceive that it is of a large lamellar form, or such that one of the lateral dimensions is always much greater than the other, the leading lines being nearly vertical. The cross fracture by which it is separated into small masses and becomes detached, is comparatively so rare as not to give any general feature. If it is possible to transfer a term from a hand specimen to a rock, I might say that it was formed of distinct lamellar concretions, and a perfect idea may be acquired of it by conceiving the lamellar pitchstone of Arran magnified to the requisite size. It contains some caverns, formed in a vertical direction, but whether by a falling out of some parts, or a subsidence and consequent separation of contiguous ones I could not determine. I have already said that its texture and aspect are very various, its varieties occurring as far as I could perceive without any certain order or regularity. Its basis appears to be a felspar, occasionally of the compact sort, but more generally crystallized in a confused manner. It differs much in colour, and offers the following remarkable varieties, brown red, umber brown, iron grey, purple brown, ash colour, yellow green, olive green, pale grey green, and grass green. The crystals of felspar which are imbedded in the mass are of a small size, rarely exceeding the tenth of an inch, and are either grass green, brown, or white. Nodules of green earth are also found imbedded in it, and the green varieties appear to derive their colour from this substance.

I have contented myself according to the established language with calling this rock by the simple name of porphyry, a name so vague, and so carelessly applied to rocks of widely different characters, as to be a cause of unspeakable confusion. Since the term porphyry is now applied to all rocks, whatever they may be, which in a given base contain imbedded crystals of felspar, or of any other substance, it is evident that it can determine nothing with regard to the nature or true place of these rocks. An accident common to many species is not the characteristic of any. As well might granites and micaceous limestones form one species from their participation in a common ingredient. Thus we are told that Cruachan consists of porphyry, that the Ochil hills consist of porphyry, that the Calton hill consists of porphyry, and that Rona consists of porphyry. Yet these four rocks are essentially different, and separated from each other as widely in composition as they are in geological relations, bearing, in short, no resemblance except in the common and unessential circumstance of imbedded felspar. For, the hornstone, the claystone, the trap and the felspar, which constitute the bases of these several rocks, although often containing crystals of felspar, are yet perhaps as frequently destitute of that accidental substance. I am not an advocate for increasing words, and encumbering our language with unnecessary terms, but that confusion which arises from applying one term to many substances, is at least as faulty and a greater cause of error than the accumulation of an unweildy stock of synonymous ones. If we must retain the ill applied term of porphyry, let it at least be returned to its place among the adjectives, and used as the trivial name to those species, which, for the purpose of description, can only be truly characterized by their permanent composition, not by their accidental features. Thus we shall have porphyritic traps and claystones, or, if our grammatical ears are not offended by it, we may have felspar porphyry, and hornstone porphyry. These are associations of substantives at least as tolerable as that of *a line of battle ship*.

I trust it will not be considered beneath the dignity of the Society if I here take notice of the assistance which the arts may derive from some of these porphyries. The green specimens are capable of assuming a good polish, and form ornamental stones of equal novelty and beauty. We have long been indebted to foreign countries for substances which our own island produces in abundance, and in no instance have the powers of established habits and prejudices been carried further than in the preference given to many of their insignificant marbles and porphyries, while our own, either similar or superior, have been neglected. To encourage commerce and the arts is not unworthy of a Society, which, like ours, has in view among other objects, the investigation of an important branch of the natural history of our own country. Let us not suffer ourselves to be misled by the imposing aspect of independence and disinterestedness which philosophy assumes when employed in investigating general principles, and, contented with the splendour by which science is surrounded, refer to others the humble task of converting it to useful purposes. It is the chief boast of science, that while it occupies the mind in pursuits by which it is exalted and interested, it tends at the same time to better the condition of life, by adding to its enjoyments, or taking from its inconveniences.

Arran. Goatfield.

The general disposition, as well as the particular details of the geology of Arran being universally known, I need not enter into any description of them. I may merely remark, that the group of mountains which constitutes the most elevated part of this island, consists of a mass of granite, of which Goatfield is the highest point. Various ridges, separating deep vallies of sudden declivity, branch from the higher parts of the group in different directions.

These mountains are succeeded by a very systematical arrangement of consecutive rocks, terminating at length, on one side, in the sandstone which forms the shore from the Cock to Brodick Bay, and on the others, in various alternations of rocks, which it is foreign to my purpose to describe.

The granite of this group differs essentially in external features from that of the central highlands, and it equally differs from it in character, resembling almost precisely, in hand specimens, the well known granite of Devon and Cornwall.

Like that also it has the bedded appearance which in detached parts so much resembles stratification, and has not unfrequently been mistaken for it. If we were to be guided by the look of a single rock or jutting mass, taken here or there, it would be very difficult to avoid being misled by the impression of stratification which it gives. But if we examine it in a wider view, we shall see that this appearance is fallacious, and that the laminæ, rather than beds, in which it is disposed, are placed in every possible direction; exhibiting even in the immediate neighbourhood of each other, an irregularly tabular form, or lamellar texture, and not a stratified deposition. It is not even possible that these masses should be portions of disrupted strata, as their positions are complicated in a way in which no subsidence, or other subsequent disturbance could have placed them. At any rate it has no better claim to stratification than the granite of Dartmoor and Cornwall—with these it must be classed in geological as it is in mineralogical character.

As the stratification of granite has been a subject of much controversy, it is worth our while to examine those doubtful cases which may be explained by other considerations, and to see what analogies in the disposition of other rocks can be brought to bear on this question. Thus we may possibly find that this disputable appearance forms part of a series of very common phenomena, and that although it may possess a certain general resemblance to the effects of mechanical action, it is, in fact, produced by chemical agencies.

There are two circumstances to be regarded in describing the fracture and texture of a rock, its small or artificial fracture and microscopic texture, and its large or natural fracture and texture, as they are determined and exhibited by the effects of time or decomposition.

The instances which might be adduced to illustrate these differences are sufficiently familiar. In the case particularly of the large disposition and fracture of rocks, a striking difference occurs in the often approximated beds of trap and sandstone. Both form parallel beds, and both on the application of force break into nearly similar fragments, yet the natural division of the sandstone bed shows an horizontal tendency, or one parallel to the plane of the bed, while that of the trap is vertical to it. From the vertical fracture a series of gradations occurs which at length assumes the perfectly geometrical form of polygonal columns. In this case then, we have a form still more perfectly mechanical and regular than that of the most even stratification, and produced by a species of crystallization, a tendency to decided forms in those particular rocks, with the laws and causes of which we are at least as well acquainted as we are with the laws that determine the figure of a quartz crystal. At present they are both equally inexplicable. There is no further difficulty in conceiving that a rock may constitute a huge bed separable into horizontal laminæ as regular as the strata of a mechanical deposit, than in conceiving that the island of Staffa is separable into columnar fragments, or the rock of Devar into vertical laminæ. It is true that we have not yet produced any instance of continuous, horizontal laminar concretions, which are incontrovertibly not mechanical, yet its existence implies no chemical impossibility. That which occurs on a small scale may occur on a large. The terms are but comparative, and the works of Nature are not to be limited by a measure taken from our own confined dimensions.

Thus we find on the small scale, that antimony is divisible into laminæ, while its sulphuret splits into columns; that mica has a lamellar texture, and asbestos a fibrous one. Should a mountain of the size of Goatfield occur, formed of a solitary crystal of mica, we should not be entitled to call it stratified, while we considered a neighbouring mountain of asbestos to be columnar.

Such I conceive to be the analogies by which we may safely guide our reasonings on this subject. Nor is the great lamellar texture which has so often been considered as the effect of stratification, peculiar to granite. In examining the Cuchullin hills in Sky, I have observed that the syenite and greenstone are bedded as it were in layers, either curved or straight, either horizontal or slightly inclined, resembling so much the disposition of granite beds, that even an experienced eye would at a distance be deceived by them. It is not necessary to illustrate this view by any further analogies, as every person's memory will afford examples in the disposition of some kinds of porphyry. My design is merely to suggest the necessity of considering the greatness of the scale on which Nature operates, and the probable occurrence of a chemical texture, if I may use such an expression, different from, and additional to that which may be observed in the smaller masses, and probably as constant in the larger masses which constitute the different rocks, as the minuter crystallization is in the smaller parts which unite to form them.

Thus far I have only argued on the probability that Goatfield does not consist of stratified granite, by analogical reasoning and arguments drawn from theoretical principles. We have, however a perfect certainty (as far as we have any certainty in geological induction) that it is not stratified, because veins are found arising from it, and entering the mass of incumbent schistus in the well known junction at Loch Ranza.

I have not thought it necessary to take notice of the probable cause of the prismatic form which occurs so frequently on the summits of the high ridges in this granite, having before spoken of them in my remarks on that of Cornwall and Devonshire.

I cannot quit this subject without mentioning that many of the masses of granite on the summit of Goatfield, are magnetical, affecting the poles of the needle *in situ*, and influencing it also even in detached pieces. This occurrence may probably be more common in granite than we are aware of, but as yet, I believe it has been observed only in the Hartz mountains.*

Boharm.

The sappare (disthène) said to have been originally discovered in this place, is now known to be inherent in many different rocks. Thus, it has been found in granite, in mica slate, and in talc. The specimens of it seen here, occur in a vein of quartz, which traverses a talcy clay slate, a slate accompanied by a singular rock, which I will also describe. It only offers the common aspect of this mineral, which hitherto has exhibited no remarkable varieties, and is of a very decided character. The crystals of disthène occur in the quartz vein, as well as in the clay slate which bounds it, and pass indifferently through both, without

* I have since observed it in the mountain Cruachan.

any change of their direction or appearance, marking clearly a common condition in the schist and the quartz, at the period of their formation. It is also worthy of remark, as I have observed, in another place, in speaking of the rutile of Killin, that although the crystals of disthène in general penetrate and impress the quartz, they are sometimes bent and waved as if they had accommodated themselves to its irregularities. Ignorant as we still are of the mode in which various minerals are crystallized together, it is not unworthy of our attention to collect all the facts which may tend ultimately to throw light on this obscure process.

The clay slate which I have mentioned above, constitutes a large portion of the mountains which here form the termination of one of the Grampian branches in this direction; it is succeeded by a hard quartzy sandstone, similar to the rock of Assynt, before described, and by an exceedingly hard quartz breccia, in which the paste is red, and the fragments white, and which is noted for containing agates and jaspers. Immediately after this follows the red sandstone, which constitutes a great part of the flat tract of Moray, and bounds the course of the Spey in this place. It is accompanied by the singular rock above alluded to, which I am about to describe. This rock consists of a talcy clay slate, so penetrated with hornblende as to render its character for an instant doubtful. On an accurate examination, it will be seen that the body of the rock is a clay slate, and that it is interspersed throughout with lamellar and thin crystals of hornblende. These lamellæ are generally disposed at right angles to the lamellæ of the schist, and are sometimes short and straight, and variously placed, interfering with each other in every direction. More commonly they diverge from a sort of central axis, in curved planes, so that their section according to the lamellæ of the schist, exhibits an appearance of curved penicilliform groups of acicular crystals frequently an inch in length, assuming an aspect of great singularity. In this direction the schist is visible, and appears to form the largest part of the stone, while in the cross fracture the lamellæ of hornblende alone being seen, the whole rock seems to consist of this mineral. Occasionally the hornblende displays crystals disposed in so many different ways, that the schist is discernible even in the cross fracture, but this variety is the least common.

Portsoy.

The veins of granite found at Portsoy are well known, not only for the peculiar character of their crystallization, called graphic, but also because they contain crystals of schorl (tourmaline) of great magnitude. The singular disposition, and mutual relations of the crystallized substances which form this compound rock, are known to have afforded Dr. Hutton an argument for its igneous origin, and its peculiar character has been supposed to arise from a simultaneous, or nearly simultaneous crystallization of the several substances contained in it. The specimens which I have to enumerate, are such as not only throw considerable doubt on this explanation, but are in fact, sufficient to prove a sequence of epochas even in this limited space, and to show that the compound rock in question has been formed by successive operations, the nature of which however I fear we shall not easily determine. I would entreat the pardon of the Society for occupying so much of its time on the fracture of a schorl crystal, were I not persuaded that much light must at some period inevitably be thrown on the greater geological phenomena, by considering the chemical and mechanical relations existing among the smaller portions which constitute them, and that the language of Nature is often as intelligibly spoken in the minute space of an inch, as in the immensity of a mountain. It is scarcely necessary to add, that the other prevailing theory, that of aqueous formation, supposes the substances which constitute this rock to have been crystallized from a watery solution, and that the fundamental objection to the igneous explanation, is the apparently chemical impossibility, that of a rock compounded of two crystallized substances, the one which is fusible at the lowest temperature, and therefore would be the last to crystallize, should by crystallizing first, have made its impression on the other. An analogy has, I know, been offered in explanation of this difficulty, but it will immediately be seen that it is at least incompetent to explain the particular case under review.

The first specimen which I have to describe is a detached crystal of a flattened and irregular figure. It has been broken into four parts, by transverse fractures, which have again united without the intervention of any intermediate substance. Previous to this reunion however, they have all been slightly shifted, in such a way that the several parts of the fractures project, and the whole crystal has undergone a slight deviation from its original straight line. If it be alledged that this appearance could arise from a disturbed crystallization, the next specimens will remove any doubt on this head.

In these, the crystals have not only been fractured in the same way, across their axes, but the fractures are filled by the quartz and felspar which constitute the body of the rock. The granite veins of Arran do not show more clearly the ramification of a central substance through the fractures of the neighbouring rock, than these specimens show the veins of quartz proceeding from the mass, and penetrating every fissure which had been formed in the crystal. It is perfectly evident, that whatever is true of the above cited granite veins, must also be true of this rock, that the schorl has been crystallized, then broken, and penetrated by quartz in a state of fluidity. Nor is there any intermixture of the matter of quartz, with the matter of schorl, but the line of separation is most accurately drawn between them. It follows then from these circumstances, that the rock in question is not a simultaneous formation from a state of fusion, nor can we readily understand how it can be the effect of fusion at all, consistently with the chemical principles we acknowledge. Had such a mass of fused quartz invaded the minute fragments of schorl which the specimen exhibits, the latter must either have been fused into a shapeless mass, or at least the asperities of fracture could not have remained in a substance whose fusibility is so much lower than that of quartz. Those who attribute the formation of this rock to aqueous solution, will perhaps in the above mentioned specimens find arguments in favour of their hypothesis. I will not repeat the often quoted difficulties which attend this theory also, but request from it an explanation of the remaining specimens.

The first of these is from the same vein at Portsoy, and contains an acicular and detached crystal of schorl, which is bent without fracture, so as to form a considerable curvature.

As chemistry produces no examples of incurvated crystallization, I may safely conclude that this crystal has been bent by external force after its formation. The noted fragility of schorl will not allow us to suppose that it could be bent without breaking, unless it had been previously rendered flexible by some chemical agent possessed of powers which we have not hitherto discovered in water.

The other specimens are not from Portsoy, but from an interior part of the country, and exhibit appearances equally irreconcilable with the theory of the aqueous formation: but the objection on this ground has been urged before. In one a crystal of schorl passes through the centre of a garnet, and the whole is suspended (if I may use such a phrase) in the quartz. In others the crystals of schorl are simply suspended in the quartz or felspar, and have perfect terminations. It is evident in the first, and strongest case, that the schorl crystals must have been supported in a fluid of equal gravity, possessing no action chemical or mechanical on it, while a garnet was allowed to crystallize round it, and that this extraordinary state of things must have continued during the time which it would require to deposit a mass of quartz from a watery solution around the whole, a period, which if we may judge from the slow formation of chalcedonies from water, involves a supposition little short of miraculous.

Such are the difficulties which beset this very simple and probably very common occurrence. I do not mean by adducing it, to say, that no theory is worthy of attention which cannot explain all the phenomena. My wish is rather to excite the industry of those who cultivate geology, to the investigation of the still recondite chemical actions, from which alone we can hope for the solution of these and numerous other difficulties which attend us.

Loch Laggan.

I am merely desirous of pointing out under this title a bed of limestone, lying in a country so little visited, that it has not yet been observed by mineralogists, and of sufficiently rare occurrence to render it an object of notice.

The whole country about Loch Laggan is of that composition which forms the far larger part of the highland districts, namely micaceous schistus.

The bed of limestone has been quarried near the eastern end of the lake, and if the reports of the quarry-men are to be trusted, extends in a direct line for many miles. This part of its history merits investigation, as the limestones which lie in the highland schistus, are generally of very limited extent. The stone itself is remarkable for containing hornblende. The sides of the bed are in contact with hornblende slate, or rather with that unnamed and common rock, consisting of a slaty mixture of quartz, mica, and hornblende.

Where the limestone comes in contact with the schist, the hornblende crystals penetrate it in such quantity as to blacken the compound. Towards the centre of the mass they diminish in number, and at length disappear.

Mica also accompanies the hornblende to a certain extent within the bed, and the limestone being itself of a pure white, a marble is thus produced of an ornamental nature, and bearing a considerable resemblance, as well as analogy, to the celebrated marble of Tirey. A substance very much resembling massive garnet may be perceived here and there united with it, but in so small a quantity as to render the determination of its true nature difficult. It is worthy of notice, that the limestone is frequently of a large platy fracture where in contact with the hornblende schistus, and that these plates are not straight but flexuous.

Craig Cailleach near Killin.

This summit forms a part of the ridge separating the vales of the Tay, and Lyon, and is the next highest in elevation to Ben Lawers, the most conspicuous part of that ridge. The predominant rock of this ridge, is a very well characterized chlorite slate, which is, however, intermixed with rocks, consisting of hornblende, and felspar, and of micaceous schist mixed with hornblende. It exhibits therefore, specimens of the syenite of Werner, but such as are evidently associated with the mica slate family, and perfectly distinguished in their connexions, from the greater bodies of syenite occurring in Scotland, which appear in an independent position, resembling that of the trap family. The mica slate is often remarkable for containing numerous and very large cubical crystals of pyrites, an occurrence much less frequent in this rock than in clay slate.

Veins of quartz traverse it in innumerable places, and it is also interspersed with compressed nodules of quartz, which bear no marks of attrition, but are intimately united to the mica slate, or chlorite slate, in which they occur. They are frequently characterized by a beautiful transparent brown colour, which renders them objects of much research and high price among lapidaries.

Massive chlorite also appears in abundance, and it is generally interposed between the chlorite slate and quartz nodule. But the object for which I have chiefly noticed this mountain, is the occurrence in it of Rutile, a mineral as yet of sufficient rarity to deserve a record of all its *habitats*. It is found in the larger, as well as in the smaller quartz nodules, and exhibits many of its well known varieties.

The crystals generally penetrate the quartz, and often appear to have their bases fixed in the investing chlorite. It is worthy of remark, that although they most commonly penetrate the quartz, as if crystallized at perfect liberty, yet they are frequently bent, so as to accommodate themselves to its occasional elevations and depressions.

Our knowledge of the chemical laws by which mixed minerals are crystallized together is as yet so imperfect, that we can offer no conjecture on an appearance so complicated as this, which however, is not the less deserving of our attention.

Loch Lomond.

The formation of a new road on the banks of this lake, has exhibited some instances of the contortions of mica slate, which are deserving of notice. I have attempted to give a notion of them in the accompanying sketches (Pl. 31. fig. 1, 2.—Pl. 31†, fig. 3.) as it is not possible to procure specimens of the magnitude requisite for that purpose.

It would be superfluous to add any thing to the observations on the inflexion of strata, in the "Illustrations of the Huttonian theory," where this subject is ably treated. But as they consist chiefly of remarks on the continuous inflexions of extensive strata, it will not be useless to notice the more complicated curvatures which take place in the smaller masses. In a brief notice on certain waving lines of colour occurring in killas at Plymouth Dock, transmitted last year to the Society, I suggested the difficulties which attended a solution of this question, the disposition of the colour having no relation to the laminæ of the schist. But in the contortions of the mica slate, the laminæ themselves are waved, and we have only therefore to enquire into the conditions requisite to the production of this appearance.

It is evident on inspection of the sketches, and will be equally so to those who shall inspect the rocks themselves, that, if the several laminæ which compose any given mass, were to be now rendered flexible, they could not be reduced to continuous straight lines, without materially changing the relations of their several lengths, and thus altering the figures of the rocks which now contain them. It is therefore evident, that no general force acting on a large mass has been the cause of these curvatures, but that they have been produced by the application of numerous partial forces acting on different parts, and capable of stretching those sets of laminæ on which the forces have acted, independently of the neighbouring ones. It is equally evident, that a mere state of softness in the stratum of schist is insufficient to account for this partial and complicated effect, but that it must have taken place when the rock was in a state of tenacious fluidity. The effect produced by mechanical disturbance on fluid slags which consist of differently coloured laminæ, will illustrate my meaning, or, to leave out of the question any illustration which may appear to involve a cause, similar appearances may be produced by the disturbance of tenacious compounds of clay and water, or of other semifluid mixtures. It is not perhaps essential to the igneous theory, that this fact should be explained by an igneous softening; but it is necessary that the aqueous theory should admit of a disturbing force capable of producing a mechanical effect of this nature, since nothing short of mechanical force acting on yielding matter is capable of explaining it.

I may here add a fact somewhat illustrative of these partial contortions in schist, which is to be observed occurring in the basalt that forms the hill of Dun Can, in Raasa. Innumerable instances prove to us that the decomposition of basaltic as well as of granitic and other rocks, detects in them that structure which we should in vain seek in the fresh and entire mass. The weathered basalt to which I allude discovers appearances of contortion similar to those now under review, its surface exhibiting parallel prominences, separated by deep lines, which are waved in very complicated curves, and give reason to suspect a mechanical disturbing force, acting in this case also, upon a semifluid mass. As analogous appearances of curvature are also of frequent occurrence both in veins of quartz, and in veins of granite which traverse mica slate and gneiss, I have given figures of a few among the most remarkable of the innumerable specimens to be seen all over Scotland (Pl. 31 †). I have nothing to add in explanation of them; they merely suffice to prove, that these substances like the schistose rocks, have been in a state which admitted of bending; the capricious and intricate contortions visible in some of the figures (which were drawn with great care) not admitting of any fissure of this form to be subsequently filled either by injection or infiltration. One of the figures is perhaps particularly worthy of notice, on account of the distinctness with which it demonstrates the action of partial forces, by the remarkable difference of curvature occurring in two veins so nearly approximated.

Burnt Island.

A specimen of a compound vein is before the Society, which traverses the well known amygdaloid of this shore. This vein consists of a highly crystalline brown limestone, mixed with a ramified compact earthy black basalt. These substances are so intermingled, that it is scarcely possible to conceive that the basalt is posterior to the limestone, or that a basalt vein should have found its way into a vein of limestone without also traversing the amygdaloid. It is probable that the whole vein is of simultaneous formation, and that the substances have separated from each other in consequence of those obscure chemical affinities which regulate the crystallizations of compound rocks. This however is a subject deserving of further investigation, as, if it is admitted, it will prove that the same cause, whatever that be, may preside over the formation of basaltic veins, and those veined limestone deposits in trap rocks, which are called calc sinter, and are held to arise from the posterior effects of a watery infiltration.

In the same rocks a singular circumstance accompanies the imbedded calcareous nodules. Their surfaces are occasionally marked with sets of concentric circles, consisting of fine black lines most mathematically drawn, with their intervals often filled up by portions of parallel circular segments, an appearance similar to that produced on the surface of some of the agates imbedded in trap, and which on that account are called ocular. These black lines are perfectly superficial.

Crinan.

The land about this harbour is remarkably disposed in small elevated hillocks, producing an irregularity of aspect similar to that of the Oban shore. The mode adopted in making the canal, by cutting away the edges of these hills, so as to form a continuous embankment against them for a considerable space, has brought their structure to light, and given great facility to the investigation of their composition. They are formed of a continued alternation of beds, elevated to an angle of 80° or upwards, and in a general view appearing to be nearly vertical. On examining these beds, they are perceived to consist of the following substances.

1. Coarse graywacke, very well characterized, and precisely corresponding to the definition, inasmuch as it consists of grains of quartz cemented by clay slate.

2. The same rock, in which grains of felspar as well as of quartz are cemented by clay slate.

3. Coarse grained graywacke of a slaty fracture, or graywacke slate.

4. A similar rock of a much finer texture.

5. A perfectly homogeneous clay slate, not to be distinguished from the finest varieties of the primitive sort.

6. A similar slate of a pale greenish gray colour, and silky lustre, approaching in character to chlorite slate.

All these beds are traversed by numerous veins of quartz, and they alternate with each other without any regular order, the beds not forming a series passing from the coarse to the fine grained, but a fine clay slate often following close upon a coarse graywacke, and being succeeded by a similar rock.

Here then we have an instance of a fact, of which the observations of every geologist will furnish many other examples, namely, the occurrence of clay slate among those rocks called rocks of transition, their alternation rendering this part of the fact indisputable. The nomenclature of rocks therefore which is derived from geological situation, is here at variance with that which results from mineralogical character. If the unnecessary multiplication of distinctions and names in mineralogical nomenclature is productive of toil by introducing a cumbrous apparatus into the science, it has at least the merit of conducing to accuracy of description. That is a much worse extreme, which by rejecting all such distinctions confounds together under one sweeping term, all sorts of substances, which, however differing in individual character and however constant and uniform in the character each severally assumes, are associated by only one common circumstance, the accidental one of position. A mineralogical nomenclature, like that of the other branches of natural history, must either be derived from the appearances and properties of the individual species, or from the character of the species combined with some generic or family character, either natural or artificial, which may render it of more easy classification and description. But we are not at liberty in the nomenclature of mineralogy, to derive our terms sometimes from the appearance of the species, and sometimes from the accidental circumstances which are found to belong to it. This is to acknowledge two distinct principles of nomenclature, and to claim a privilege of using that which happens to suit any particular hypothesis which we may wish to support. The accurate description of mineralogical species, must be the base of all geological reasonings, but if we intermix characters derived from geological circumstances with true mineralogical characters, we set out upon a *petitio principii*, and end by reasoning in a circle. In the case of limestone, the chemical properties and well known popular characters of which have given it a very decided and constant name, we act rightly. The name of the species is retained, be its geological situation what it may, and its geological accidents are distinguished by the addition of that name which suits its position, whether primitive, transition, or flœtz. But on the other hand, a mineral equally common, whose characters too are sufficiently familiar, is distinguished by two names, although even more identical in structure than the different tribes of limestone, and it is called clay slate, or graywacke slate, for no other reason than that in the one case it is associated with the rocks called primitive, and in the other with those which go by the name of transition. It is obviously necessary that the same practice should be adopted in this case as in the former, and that, adhering to the name of the species, we should distinguish its geological position, if required, by the superaddition of the corresponding term. We shall thus have primitive clay slate, and transition clay slate, if we find it necessary to retain these geological distinctions.

It is almost superfluous to quote instances of the existence of genuine clay slate occurring together with well characterized graywacke slate, as they may be seen in all the slate counties of England, and among others remarkably in Cornwall. I trust that the geologists who have attended to these rocks, will see, with me, the necessity of adopting this distinction; a distinction, without which all accuracy of discrimination will otherwise be sacrificed to the maintenance of an hypothesis, and the student whom it is a duty incumbent on our Society to assist, will learn to adopt that hasty and slovenly nomenclature, which is destructive of correct description, and scarcely less inimical to accurate observation.

Having said thus much on the very ill apprehended and often ill applied term graywacke, I shall be pardoned for suggesting the propriety of limiting it by a certain fixed definition. Different observers have classed under it, substances the most discordant, looking either to their general geological hypothesis, or finding it a convenient repository of rocks for which no other name was at hand. Thus it has become a chaos of ill associated substances. Because Cumberland and Wales are supposed *countries of transition*, almost every rock found in those districts has been occasionally called graywacke, and thus we have had breccias of all possible modifications, sandstones, and clay slates, comfounded with genuine graywacke under one common designation.

The definition of Werner appears precise, and I believe I do not misapprehend it, when I state that its essential part is to possess clay slate as the cement of certain mechanically altered grains or fragments of different rocks. These may vary materially in size, and thus form the two leading varieties of fine and coarse graywacke, and if they also possess a fissile structure, they will then constitute fine and coarse graywacke slate. It is true that in the definition of Werner, as given us by Jameson, the grains are stated to be quartz, indurated clay slate, and flinty slate, but since felspar and fragments of other rocks do occasionally occur in the best characterized graywacke, it would probably be desirable to extend this part of the character so far as to include all grains and fragments, of whatever nature they may be, and to consider the cementing substance, and obviously mechanical structure, as the essential part of the definition. I shall take an opportunity in some remarks on another district, to enquire whether it would not be also convenient to extend the definition so far as to permit mica slate to participate with clay slate in the office of cement, the other parts of the character remaining the same.

Whatever definition be ultimately adopted, we cannot too strongly inculcate the necessity of accuracy in the application of terms. Accurate mineralogical knowledge is an indispensible condition to accurate geological description, and the errors of very modern and celebrated authors, arising from the want of this fundamental quality, are too well known to call for the invidious task of pointing them out.

The cacophony of the term graywacke has excited a desire in some late observers to discard it altogether, and substitute one more vernacular, and less liable to that objection.

The multiplication of synonyms is itself an evil of so crying a nature, and has unfortunately become a disease of such magnitude in our science, that we ought to consider well before we venture to add another to the unwieldy and vexatious stock. It is so great an advantage to possess one term well understood, and understood as the language of philosophy should be, in all countries, that we can scarcely find a motive sufficiently powerful to induce us to change this received name. Under these circumstances we have every reason to retain the term graywacke, however jarring to English ears, and it is the excess of fastidiousness to reject on account of its sound, one word from such a polyglott of unmelodious and ill compounded Greek, French, and German terms, as assail the mineralogist on every side. If there is in any case a choice among equally established terms, it is in our power to chuse the most musical, but we are not justified in changing them for so slight a convenience. The late introduction of a new chemical nomenclature, has possibly, in conjunction with other causes, excited a taste for neology, which it behoves us to restrain by every method in our power, and it is the duty of our Society to watch over and protect the science from those changes which will, if not restrained, shortly inundate us with as many names as we have writers.

The word *killas*, a vernacular and Cornish term, has been proposed as a substitute for graywacke. If killas were actually graywacke, we might have a fair plea for using the name given to it by a Cornish miner, in lieu of the corresponding one of a German miner. But this is not the fact, as those who are conversant with Cornish terms, well know that killas is applied to all the soft and fissile rocks occurring in Cornwall, whether clay slate, or graywacke slate; and that it is never used for either when they acquire the more compact and laminated form of roofing slate, a term as commonly applied to this variety in that county, as in other parts of England. The harder and more granular graywacke, is also called elvan, in common with trap, and other hard and dark blue stones.

Aberfoyle.

It is well known that the ridge of which Ben Lomond forms a part, consists of micaceous schistus,* which terminates near Drymen in the highly elevated range of breccia that separates the primitive from the secondary country, and which may be traced from this

* In the Mineralogy of the Scottish isles, it is said that the summit of Ben Lomond consists of gneiss. It is necessary to correct this oversight, the whole of the mountain being formed of micaceous schistus, and no gneiss occurring in the neighbourhood.

point in various places round by the east coast to Troup Head. It is visible at the pass of Aberfoyle, and possesses a character and situation similar to that which it exhibits at Drymen.

A ridge, parallel to that of Ben Lomond, is separated from it by the valley which includes the Forth. A second parallel valley contains Loch Ard and Loch Chon, which pour into the Forth at Aberfoyle a tributary stream of equal magnitude. To the east this is again bounded by a second ridge, nearly parallel to the first, of which Ben Venu is the principal elevation. The valley which lies at the foot of this ridge, contains Loch Ketterin, having for its eastern boundary a double ridge, of which Ben Ledi is the chief eminence. These four ridges appear to ramify from a central point, situated between the top of Loch Ketterin and that of Loch Lomond.

The whole of this country has been supposed to be of the same formation as Ben Lomond, namely micaceous schistus, a supposition which I have found to be groundless. I am ignorant of the nature of the ridge which separates the vale of Loch Ard from that of the Forth, the nearest in order to the ridge of Ben Lomond. But on examining the vale of Aberfoyle, as far as from the breccia to the bottom of Loch Chon, I found it to consist of alternations of graywacke, and graywacke slate, with clay slate, similar to those I have described as occurring at Crinan, and placed with equal irregularity of alternation. The beds are also elevated to high angles, but I believe that the positions are various. In traversing the ridge which separates Loch Ard from Loch Ketterin, the same rocks appear, and quarries of fine roofing clay slate are wrought in various parts of it. These, I believe, are of the same class, and belong to the transition clay slates, but the whole ridge is so extensive and broken, that it is extremely difficult, if not impossible, to obtain access to it, except in a few places. On reaching the shores of Loch

Ketterin,* the nature of the rock alters, and it assumes an aspect approaching here and there to mica slate, but it is still characterized in most places by the true graywacke structure, that is to say, by grains united by a cement, the cement in this case consisting of micaceous schist instead of clay slate. At Ben Ledi the structure still more resembles that of mica slate, insomuch that but for the previous examination of the adjoining district, we should not suspect it to consist of any thing but genuine mica slate. Beyond this, and to the east of Loch Lubnaig, occurs true mica slate which constitutes the whole of this district as far as Perth. I may remark too, that the graywacke of which the character is so perfect in the lower parts of the vale of Loch Ard, becomes micaceous as we ascend the course of the stream, and that in the upper parts of the valley, it is often very difficult to ascertain under which head it is to be ranked.

Those who have been engaged in similar observations on an extensive tract of country, well know how difficult it is to fill up all the chasms which the nature of the ground forms in the pursuit of a series of rocks. Yet I have very little doubt that a true gradation exists here, between mica slate and graywacke slate, and that the usual intermediate member, primitive clay slate, does not occur as a necessary part of the series, but that it is irregularly alternated with the graywacke. It was with a view to these rocks, that I suggested the propriety of extending the definition of graywacke, so as to include those which contain mica slate, talc slate, and chlorite slate, as the cement of the grains, instead of limiting it to clay slate alone. In many of the rocks which occur here, the cementing ingredient appears to consist of these several substances, the rock in

* Ketterin the same as Kerne used by Shakspeare—banditti; hence Loch Ketterin, and not Kathrine or Catharine as it is erroneously spelled.

other respects preserving a perfect graywacke character, and being composed of distinctly rounded as well as crystallized grains of quartz, joined by a common cement.

It is plain that there will be a point of gradation where it will be impossible to say to which of the two the rock in question ought to be referred, although the extremes are perfectly characterized, in the one case by the laminar form of the quartz and mica, in the other by its granular disposition. I shall not be surprised if future observers discover that the rocks of the graywacke structure alternate here with those of the micaceous schist. Should this be the case, it will confirm the supposition which I have suggested in other parts of these papers, that no real and well defined line of distinction exists between the transition and primitive rocks, but that they form a graduating series of one single *formation;* a series so gradual as to render it expedient once more to return to the most simple division of rocks, into primary and secondary.

XIX. *Remarks on several Parts of Scotland which exhibit Quartz Rock, and on the Nature and Connexions of this Rock in general.*

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Jura.

As I considered that the mineralogical history of Jura had already been amply detailed, I ascended its well-known mountains rather to gratify my love of the picturesque, than with the hope of acquiring any new ideas on the subject of its structure.

Yet as the predominant opinions seemed to have determined that the tract in question was composed of a granular quartz, and as it had been compared with the northern part of Scotland asserted to consist of the same rock, with the ridge of Schihallien, amply described as such by Professor Playfair, and with numerous other foreign rocks described by various authors under this designation, I had with others admitted the term, and the æra of formation which this term implied. My own researches having given me reason to differ in opinion from these authorities, I have thought it necessary to describe the appearances which I saw; the question of its rank in the great society of rocks can only be determined after all its circumstances have been fully investigated.

The whole island extending to a length of 30 miles, and varying in breadth from one mile to six, is fundamentally composed of this one rock, which is also to be found extending through Scarba on its northern, and through a great portion of Isla on its southern shore. The other rocks which occur, with the exception of an important series to be immediately described, either occupy small spaces apparently subordinate to the general mass, or consist of veins which traverse it. The highest part of this tract forms an irregular elevation, of which the three well-known Paps of Jura attaining the height of 2500 or 2600 feet, are the most remarkable and prominent features. These occupy a point in the island much nearer to the southern than to the northern extremity. The interval between them and the southern shore is low, the mountains declining with a tolerably uninterrupted slope to the sea. But that between the Paps and the northern side is occupied by a succession of hills which also decline gradually from the highest elevation, and form a broken ridge extending to the northern shore of the island. If we look from any of the highest summits towards the north, a view of almost unexampled singularity and grandeur is afforded. A series of ridges and broken elevations appears under the eye, but so far beneath it that their irregularities are nearly lost in the continuity of the straight lines which guide the sight to the further extremity of their range. These seem to rise from beneath the feet, and to converge to a distant centre, according to the strict laws of perspective. On investigating the cause of this striking disposition, it is easy to perceive that the effect is produced by the disrupted edges of strata of rock rising from the east at a considerable angle, and broken away towards the west.

However much the continuity be here and there apparently interrupted by the predominance of some particular hill, it is obvious on comparing these apparent interruptions with the actual causes which produce them, that the fundamental evenness and direction of the strata is no where altered, and that their discontinuities are only the effects of partial elevations interfering with the visual line, all the strata being straight and parallel to each other through their whole extent. This line extends to the north north-west, and the strata dip to the east north-east. In the Outlines of the mineralogy of Jùra, this angle is said to be 45°. It appeared to me considerably less, but this sort of observation is not easily made, except in favourable circumstances of position, and I was at no pains to verify it accurately, considering it of no importance in a case like this, whether the elevation were 10 or 12 degrees more or less. It is only in cases where it is necessary to compare particular strata, either with the neighbouring ones or with each other, that accuracy is required, and this accuracy is I fear much less frequently attained than pretended to. These strata are generally thin, often not exceeding six or eight feet in thickness, and I no where observed that they were distorted or interrupted by veins of any magnitude, or that they alternated with other rocks. It is true that at an inaccessible part of the summit of the one on which I stood, I observed a mass of dark-coloured rock, which the guide informed me was a slaty stone. Future observers may find detached specimens of it, and thus ascertain that which I attempted in vain to investigate, but which the sequel of these remarks will prove to be more than probable.

Such is the appearance of the rocks as observed from the Paps of Jura. In descending to the lower grounds, the stratified disposition becomes more obscure, in consequence of the interruption to the continuity of the rock from the thick covering of heather, and from the irregular form of the surface which prevents a connected view of large tracts. In many parts of the shore, however, the disposition of the strata is evidently changed, and they are observed occupying every possible variety of position, from the horizontal to the vertical. The steps by which these changes succeed each other eluded my observation, and perhaps are not to be traced.

I will now describe the principal modifications which this rock assumes, so as to give an idea of its mineralogical character, before I attempt even to conjecture its place in a geological system.

It exhibits the following varieties:

1. An extremely compact granular stone, consisting of grains of quartz, of unequal sizes, united without cement.

2. The same, containing grains of clay, which appear to be decomposed felspar.

3. The same, with more numerous grains of felspar, which appear on examination generally to consist of rounded fragments.

These rocks are traversed by veins of quartz, of which the aspect is also granular, but they are distinguished from the body of the rock by their snow white colour. They often appear so incorporated with the rock that the line of separation cannot be distinguished.

4. A similar rock containing angular grains of quartz of half an inch in diameter, and bearing every mark of having been formed from a disintegrated granite, except that it exhibits no traces of mica.

5. The same rock containing a flattened oval pebble of quartz, perfectly smooth, and having uniform curved surfaces, as if from long attrition. The pebble is two inches in length, and one and a half in breadth. It was so firmly united to the rock, that on one side it has been broken in the attempt to separate it.

6. Grey quartzy rock, with a basis of a compact splintery appearance, containing imbedded grains of transparent quartz.

7. Small grained breccia, of which the basis is an earthy-looking mixture of felspar and quartz, resembling claystone, or compact felspar, and uniting angular and rounded fragments of quartz.

8. An uniform aggregate of large grains of felspar and of transparent quartz, without the aspect of granite, since all the grains appear to have been mechanically rounded and re-united.

This quartz rock in the several varieties now described, although as I have already remarked, it forms the essential and fundamental part of the island, does not occupy it to the exclusion of all others. Beds of a rock resembling both mica slate and graywacke, of common graywacke, of finer graywacke slate, and of perfectly fine and uniform clay slate, together with beds of chlorite slate, appear in various places, all difficult to trace through their whole bearings, yet all apparently superimposed on the quartz rock. It is necessary to describe these rocks somewhat more particularly, as they are intimately connected with the quartz rock, and serve to illustrate its history. The following are the most remarkable varieties:

1. A mixture of quartz in grains, with mica slate, of a character intermediate between quartz rock and mica slate, or rather resembling some of the varieties of that graywacke which I have described in my account of Aberfoyle, (p. 447.)

2. The same, of a much larger grain, with distinct scraps of mica slate.

3. The same, with the mica slate so predominant that the compound forms a dark rock, in which the grains of felspar and quartz bear a small proportion to the slate.

4. The mica slate still increasing, and the texture still granular.

5. The same, with a slaty fracture.

6. Coarse graywacke slate.

7. Fine ditto.

8. Perfectly fine and uniform clay slate, of a dark blue colour.

It is important to remark, that the beds which are found at the foot of the mountain, are of a coarser texture than those at the summit, and these are probably the uppermost beds of the deposit. Many of them are nearly black from the quantity of clay they contain; in others are found grains of mica, and in some there are imbedded large fragments of clay slate and chlorite slate.

In hand specimens a gradation may be traced from the finest and most compact quartz rock, down to a perfect breccia, containing fragments of slate, although the ground does not admit of our tracing the sequence of the beds.

If therefore we consider the circumstances which I have described as existing in the finest quartz rock, the rounded pebbles of quartz which it contains, and the gradation that may be traced in it through all the series which I have above noticed, and which are generally confounded under the term graywacke, we need not hesitate to conclude that the quartz rock of Jura is a mechanical deposit, or a rock recomposed from the fragments of older ones. I know that authors have talked of primitive sandstone, and even of primitive breccia, but the awkward nature of this compound renders it desirable that we should, if possible, discard a phraseology which involves a contradiction in terms. It is perfectly true that many of the beds in Jura contain large tracts of a granular quartz, often very pure and compact, and which from its crystalline texture might in the hand be supposed a primitive and chemical deposit; but the occurrence of blunted fragments, and of rolled pebbles, suffice to shew, that like many other rocks it possesses at least the compound structure both of a chemical and of a mechanical deposit. Neither is the perfect crystalline texture of quartz any proof of a primitive formation; since the strata of Kirkaldy, which belong to the flœtz and coal *formation*, contain beds of highly crystalline and translucent quartz, alternating with coal and organic limestones.

The mode in which the felspar exists in this rock proves also its mechanical construction, and shews that it has very probably been derived from the wearing and deposition of antient granites, by whatever means we may attempt to account for its present highly compacted and often crystalline structure.

Having thus, as I trust, clearly proved that the rock of Jura is a recomposed rock, as far as regards its structure, and that it cannot from its compound nature be properly entitled to the name of a granular quartz, it is our business to consider its geological appearances, and the probable nature of the process by which it acquired its present disposition.

Before examining this question, it is requisite to premise an observation of professor Jameson, whose accuracy is not doubted. He remarks that the " Quartz rock rises at an angle of 45 degrees from under the micaceous schistus." Here then we have a rock formed of a mixed mechanical deposit, lying under a rock which is held to be primitive, and the third in succession from the first and fundamental of all rocks, granite. I did not observe this fact, but have perfect reliance on his observations, because they coincide with what I have myself observed in other places. Either then this mechanical deposit must be considered as a primitive rock, or micaceous schistus is a rock of more recent formation than it has been generally esteemed.

This latter supposition may perhaps admit of further proof, but I cannot enter into it in this place.

Leaving this additional difficulty out of discussion at present, it is obvious that there is no provision made for this rock in Werner's classification, if I have succeeded in proving that it is as little entitled to the name of quartz, as to that of granite, and that it is not a purely primitive and chemical deposit. Its mechanical structure deprives it of a right to the latter title, and its connexions and disposition prevent us equally from arranging it with the latest stratified or "floetz" rocks. If it is a necessary condition of the "transition" rocks to contain organic remains, then this rock is also excluded from the intermediate or transition class, as much by this as by its position in respect of the mica slate, universally esteemed among the primitive, or to speak more properly among the most ancient rocks.

Such are the inconveniences of artificial arrangements, whether they are groundless, or founded on partial views of natural productions. It has been proposed indeed to call this rock graywacke, a quartzose graywacke. But this is in fact to confound all distinctions for the sake of an adherence to a system, which may without disgrace admit a new member into any of its series, should it appear that a member hitherto unobserved does actually exist. The name graywacke has been already too much abused, and is become a fruitful source of confusion and error. It is incumbent on us to diminish instead of increasing this evil, by a more careful application of that, as well as of other geological terms, and by limiting its use within the rigid compass of definition. On that definition I need not now insist; nor will I attempt at present to assign the true place of the quartz rock in the general arrangement. It will be done with greater facility when I have described its connexions in the other places where I have observed it.

Assynt.

Although I have to regret the limited extent of my observations on this district, yet as they tend to illustrate the nature of the rock which forms the subject of this notice, I am unwilling to suppress them. They may at least serve, in conjunction with the remarks which I have made on this rock in other places, to extend its history and connexions, as well as to stimulate future observers possessed of better opportunities, to continue this inquiry, and to assist in determining the composition of that extensive and as yet little known country which constitutes the northern mountainous division of Scotland.

The mountains which form the districts of Coygach and Assynt may be distinguished even from the island of Sky, by their peculiarly smooth and conical outlines, and by the whiteness of their summits, so dazzling in the sunshine, that to a spectator unaware of their composition, they appear as if for ever retaining the snows of winter. Their strong resemblance to the Paps of Jura, both in the even unbroken line which forms their summits, and in the peculiarity of their colour, immediately however, explains their composition and confirms their similarity; for, like those mountains, they are formed of a rock which has here also been called "granular and primitive quartz." In a distant view they are remarkable too for another peculiarity, which in other situations has been supposed characteristic of the mountains of this class, and that is, their detached position. The accompanying sketch of the coast, Pl. 32. fig. 2. will better explain than words can, both the singularity of their form and that independence of position which they assume; circumstances which when compared with the irregular outlines and crowded groups of granitic and schistose hills, will strike the most careless observer. The sketch to which I refer, will doubtless also remind the spectator of the view given in Dr. Fitton's paper, of the hills in the vicinity of Dublin. The conical form of these hills appears to arise partly from the rapidity of their decomposition, as far as regards their mountainous bulk, and partly from the permanent nature of the resulting fragments. To the same cause also is owing that particular and arid appearance of sterility, which is so characteristic of this class of mountains, an appearance which those who have seen Jura will readily recognize, combined with a difficulty in ascending them, which the geologist who has laboured in the attempt will not easily forget. The peculiar whiteness which the surfaces of the fragments show is however adventitious, as the fresh rock exhibits a variety of grey, yellow, and brown tints, which long exposure to the atmosphere will ultimately bleach. A narrower examination of unaltered specimens would possibly have prevented mineralogists from ever applying to this rock the improper designation of granular quartz, how much soever the weathered surfaces may resemble this substance.

On a nearer inspection, these mountains appear to consist of a stratified rock, or to be formed of various beds of grit, which, where the declivities are so steep as not to admit the lodgment of fragments, become easily visible. In my remarks on Jura, I have described a distinct and continuous bearing of the strata, but I was unable by the aid of a spying-glass to perceive at any of the various points from which I viewed the mountains of this coast, a similar tendency through any considerable space. I should conceive their tendencies to be exceedingly various, and that no general system of inclination or direction predominated among them. But of this I must needs speak with much diffidence, as I had no opportunity of ascending any of the summits, from whence alone an accurate observation of this nature could be made. Those who have been occupied in similar investigations well know how difficult it is to ascertain the disposition of large tracts of country unless observed from situations so elevated as to raise the spectator above all the obstructions which the varying forms of high ground throw in the way of this great natural perspective. The remarks of Saussure on the highest summits of the Alps, which relate to this subject, are well known. It is not material to the purpose of determining their stratified structure, whether this stratification be continuous for a large space or whether it be various and interrupted; however desirable it might otherwise be to ascertain its disposition over the whole extent which these mountains occupy. From the low positions in which I was compelled to view those strata which I saw at hand, they appeared to be in some places horizontal, in others occupying various angular elevations, sometimes inclining to the north, and sometimes in a direction the very reverse. Such perhaps would also have been my opinion of the strata of Jura, had I not attained its highest summits. Future observers who shall ascend the Cuniack hills, the Sugar-loaf mountain, or Ben More, will be able to ascertain what I have left undone. Want of roads, want of horses, want of population, want of every thing, render this country among the most impracticable of Scotland.

The nature of this rock is exceedingly various. It is often a compact stone of a yellowish colour, and uniform texture, resembling a granulated quartz, simple in its composition, and breaking with an imperfect conchoidal fracture. Occasionally it assumes a coarser and looser texture, and in these cases the weathered surface becomes white, and acquires a harsh and sandy feel and aspect. However uniform the fresh specimens appear when broken, they almost invariably disclose some internal mechanical arrangement on weathering, which betrays the nature of their original formation, a circumstance highly instructive with regard to the composition of many other rocks. Of these natural analyses, a very common one is the appearance of laminæ of red and white matter, alternating either in flat plates, or in that peculiar undulating form so well known in the *floetz* sandstones, and marking the action of water on loose sand. An occurrence of equal importance and greater singularity is that of imbedded cylindrical bodies which they occasionally exhibit. I may previously remark that they have a frequent tendency to break into rectangular solid masses, similar to those which occur in many floetz sandstones. In these fragments the weathered surfaces present on the upper part, or that which forms the plane of the stratification, a number of circular protuberant spots, apparently arising from the circumstance of their hardness being greater than that of the general mass. The lateral plane of the same fragments exhibits on the other hand a similar number of corresponding cylinders, of a hardness in the same way superior to that of the surrounding parts. If I might venture on a comparison as vulgar as it is explanatory of this appearance, I would compare it to the two sections of a piece of larded meat. I may further add, that in these cases the cylindrical bodies are of a much whiter colour, as well as of a more compact texture than the rest of the stone; and that on breaking the stone to examine further into this structure, the whole disappears, and an uniformity of texture is exhibited throughout.

This peculiar appearance is familiar to all those who are conversant in the varieties of *floetz* sandstone, and the superior hardness of the cylindrical or vermicular bodies in the sandstones of this class is equally notorious, as they often continue to project for the space of even half an inch beyond the decomposing rock, appearing as if nails had been driven into it. The coast of Fife about Burnt Island affords excellent examples of this fact. I know not that any attempt has been made to explain this circumstance in the *floetz* sandstones, but it probably arises from the remains of some animal, a Sabella, or other marine worm. Whatever it be, it is sufficient to establish the similarity in the original structure of this mountain rock, with that of the present floetz formation. I am the more particular in calling the attention of the Society to these resemblances, because I am unable to produce such decided instances of rolled pebbles as I have described in the rock of Jura, and am therefore apprehensive that the arguments by which I would prove the recomposed structure of this rock, may not appear sufficiently conclusive. But I have little doubt that many instances even of this occurrence, will be found by those who may have more time to bestow on the investigation, and who with better fortune may collect such specimens as might easily have eluded my cursory search. Proofs however are not wanting of mechanical attrition in the component parts of many beds of this rock, although the fragments do not absolutely reach the size of a pebble. A rock resembling ferruginous sandstone, of a highly compacted nature, is found in beds, alternating with the finer and more compact quartz rock, the grains of sand and gravel bearing most evident marks of attrition; and the whole mass being indurated to such a degree, that a hammer makes no more impression on it than it would on a mass of iron. It is still more satisfactory to find in certain positions, strata of absolute and perfect *breccia*, similar in aspect to those which now alternate with our older *floetz* sandstones, but possessing the same extraordinary degree of hardness which I have just noticed. If there are any marks of organic remains in this rock less equivocal than the vermicular structure which I have described above, I did not see them, nor do I consider them necessary to establish its character, since our oldest floetz sandstones are equally destitute of them. Under all these circumstances both of position and of structure which I have detailed, I think that I am justified in considering this rock, like that of Jura, to be a recomposed, and not a purely chemical deposit, being with it equally ill entitled to the name of granular quartz. Its characters would seem to prove that it has originally been a stratified sandstone, which by some of the revolutions of this globe has been both chemically and mechanically altered, consolidated in some places to the apparent loss of its original texture, and so changed in its position as to show but faint indications of its former regularity.

It now remains to enquire into the connexion of this rock with those which accompany it, a part of the subject, and a very important one, on which I must regret that I have so little precise information to offer. On the sea shore at Kylescuagh, and on the shores of Loch Lowie, a very indurated and compact gneiss appears to lie immediately below the quartz rock, but I could not discover their connexion. In the very centre of the district I found hornblende slate, gneiss, mica slate, and syenitic granite, together with numerous veins and detached masses of compact epidote. Here also, unfortunately, I could not trace their connexion. Such is the meagre account I have to render of what it would be of prime importance to ascertain, whether these rocks are every where inferior in position to quartz rock, or whether the older schistose rocks do not here, as in other places, alternate with it. Circumstantial evidence renders the latter probable. In the description of Jura I have remarked that mica slate does, according to Professor Jameson, lie above the quartz rock, and Williams considers the rock I have described, which he also calls granular quartz, to be, like granite, the rock on which micaceous schist usually rests. Professor Playfair also in his *Illustrations*, (P. 166,) speaks of a " granitic sandstone in vertical beds," and mentions its alternation with " micaceous and other varieties of primitive schist." Since this paper was originally drawn up, I have seen the country he here quotes, (Arisaik) and have confirmed that his "granitic sandstone" is the rock which I have been describing, and that it is the same rock which he has also described as constituting the ridge of Schihallien, a place of which I shall presently have occasion to speak. Possibly these authors, impressed with the notion that this rock was a "granular quartz," and that granular quartz was a primitive rock, have not thought it necessary to push their investigations as far as they might have done, nor made the important deductions which must needs follow from this fact if proved. On the geological consequences which would result from its being established it would be useless to speculate till the fact be fully ascertained, as I trust it will be in the sequel of this paper, but it is obvious that it would occasion the removal of mica slate out of the chemical deposits of the Wernerian system, and place it among the mechanical, or at least the mixed ones: a change which seems to be called for by many other circumstances attending the formation of mica slate. But I must leave this part of the subject for future consideration.

The true nature of this rock being now, as I trust made out with regard to Jura and the western part of Sutherlandshire, we are next led to inquire what evidence there is to prove that all the mountains of "granular quartz" are not of a similar nature, and do not belong to some of the ancient recomposed rocks. The mountains of Scuraben and Morven are cursorily described by Jameson, the former as having a summit of quartz, the latter as possessing the peculiar white aspect so characteristic of the hills I have noticed on the western coast; and in his work on Geognosy, they are actually quoted as examples of quartz rock. Mr. Pennant too, although not an authority in a case of this nature, describes quartz about Loch Broom, and more cursory observers have given us reason to think that the generality of the higher mountains of this northern tract of Scotland are composed of "quartz." There is little doubt that the whole of this elevated tract is of the same formation as that under consideration, and it ought therefore perhaps (according to the remarks I have already made on Jura) to be ranked with the *Transition rocks*, if we adopt the divisions of Werner.

If this be proved it will be highly interesting to ascertain the positions of all the strata throughout this whole district. Of the unstratified rocks it will always be difficult to determine what portion has been removed, or what changes of the original position may have taken place, as we have no guide to conduct us in our judgment, ignorant as we must generally remain of their original forms. With the stratified rocks the case is otherwise, their existing forms furnishing us with a palpable index, by which we may discover either the changes of position they have suffered, or the waste they have undergone. Certainly the north-west coast of Scotland gives evidence of an enormous waste of the surface, and opens an ample field for the speculations of those who have attempted to assign the causes of that waste: to them I must at present leave it.

I have already, at the beginning of this paper, remarked the similarity which the outline of the mountains of Sutherlandshire bears to that of the Wicklow mountains. These, in the paper of Dr. Fitton, above mentioned, are also called granular quartz. As I have neither seen the mountains themselves, nor any specimens from them, I am unable to decide whether they are actually similar in structure and geological character to the Scottish quartz mountains, and I can only suggest their suspicious aspect, as a reason for a further examination of them. I am inclined to entertain the same doubts relative to the quartz mountains described by authors in various parts of the world, most of which exhibit the detached and conical forms so often mentioned, and from some of which specimens have come to my hand precisely similar in their mineralogical characters to those which I have described. If such should be the fact, the necessity of finding a place for this rock in the list of formations will be more apparent than before, and it will be the duty of those geologists who lay stress on such distinctions, to ascertain the true rank it ought to bear in their system.

Schihallien.

This mountain, already highly interesting from the important geometrical operations performed on it by Dr. Maskelyne, and the subsequent mathematical computations of Dr. Hutton, has again been called into notice by Professor Playfair, in his Lithological Survey, established for the purpose of correcting the results deduced from the labours of those mathematicians.

As Mr. Playfair's remarks on the geological structure of this mountain, although chiefly referring to the particular physical object he had in view, seem to involve some important conclusions respecting the rock described in the two foregoing memoirs, I shall, I trust, be excused for stating the considerations to which they have given rise, and to which I have already alluded, since they may serve to call some further attention to its mineralogical and geological history.

The mountain itself forms the most elevated part of a ridge which may be considered as rising near Fascally, and extending in a southwesterly direction till it meets that complicated group from which the ridge bounding the southern side of Glenco takes its rise. This ridge contains the other considerable elevation of Ferrogon, and separates, not the " valley of the Tay" but that of the Lyon from that of the Tumel. The reason for making this correction will appear in the sequel.

Mr. Playfair's accurate description of the spaces occupied by the rocks which constitute the summit of Schihallien, renders it unnecessary for me to enter into any such detail. I may merely remark, that by his report the whole of the mountain, except the central ridge, consists of the various modifications of mica slate, hornblende slate, and the usual associated limestone, which are so well known as constituting the greatest tracts of the highland mountains. The result of my own examination, which was however exceedingly limited, coincides with his. All these strata are vertical, or very nearly so, and the central ridge, or the " granular quartz," appears to be placed in a position absolutely perpendicular.

This quartz rock is stratified, although vertical, in beds which, as far as they can be seen, appear absolutely and nicely parallel, their lines of separation being defined with a most mechanical exactness. They have a tendency to break into rhombic and prismatic fragments, by fissures perpendicular to their stratification, and being thus broken, they have fallen on all sides around the summit, producing the same appearances as those exhibited by the Paps of Jura, and the mountains of Assynt, and, for the reasons which I have assigned in my observations on these hills, contributing to form that elegant conical outline for which the summit of Schihallien is so remarkable.

An ample account having been given by Mr. Playfair of all the modifications of this rock which he could observe, it will be superfluous for me to enter into its history, particularly as I have already pointed out its leading characters in describing the rock which forms the summits of Jura. There is, in fact, no essential difference between them, as they consist in both cases of highly compacted grains of quartz, with interspersed grains of felspar, often earthy, and never, I believe, so perfectly crystallized as they are in granites and porphyries, but having the aspect of fragments rather than of crystals. I did not meet with any specimens on Schihallien of a formation so decidedly mechanical as those which I have described as occurring in Jura, but must rest the proofs I am desirous to bring forward of the mechanical and therefore secondary structure of this rock, on other and more circumstantial evidence. Possibly future observers, bearing this doubt in their minds, may with more time and opportunity discover such positive proofs of this nature as I failed to find, since our acquisitions in specimens are generally in proportion to our previous knowledge.

It will doubtless be admitted that if of two rocks precisely similar in the generality of hand specimens, similar also in structure and position, and possessing the same characters in general aspect and disintegration, the one is proved to be a mechanical deposit by its containing rounded pebbles or beds of breccia, it affords a very strong presumption that the other is of the same nature. But we have yet to see what further evidence of this may be found in the neighbouring rocks, as the occurrence of a single bed of a recomposed rock in a situation so remarkable as the ridge of Schihallien, might excite rational doubts, unless we could discover a greater extent of similar rocks connected with it. It is here necessary to remark that the whole country to the north of this ridge consists for a considerable space of rocks of the class called primitive. The vale of Tumel and the hills which bound it are composed chiefly of mica slate, which continues till it meets the granite of the central Grampians. The case is different on the southern side of Schihallien.

The ridge of Ben Lawers, it is true, (that ridge which does actually bound the valley of the Tay) consists of chlorite slate, with mica slate, and the other rocks of this character which need not be described. But the valley of the Lyon exhibits a formation totally different. The river Lyon runs with a very gentle fall through the greater part of its course into the Tay, proving that there is no very great difference of level between their respective vallies. In passing through Glen Lyon, the mica slate may be seen terminating on the south side of the river, in some places indeed long before it meets the bottom of the southern side of the valley. It is also obvious that the boundary of almost the whole northern side, as far at least as from Meggarney to Fortingall, consists of a sort of compact sandstone or " granular quartz," a rock in no way differing from many of the varieties of quartz rock already described. This is the ridge which declines from the south of Schihallien, and which is intimately connected with the main ridge of that mountain. The sandstone itself exhibits a texture of infinite variety, but in all cases it possesses the same aspect of antiquity and induration which characterizes the rocks of Jura and Schihallien. It would be necessary to traverse the whole of this ridge to the top of Schihallien before we could ascertain positively whether the rock which forms its summit is connected with that of Glen Lyon, and what is the mode of this connexion; a task of considerable difficulty. Yet I have very little doubt that they are parts of one great deposit, similar to that which constitutes the north of Scotland and the Island of Jura.

Future and more extended investigations may perhaps enable us to assign even from this spot the relative antiquity and position of a rock hitherto but ill understood, and possibly from the more accessible parts of Schihallien determine the very important fact of its inferiority to, or alternation with, mica slate, a fact which however will appear fully determined by the other examples of this rock, which are described in the supplement to this communication. But this circumstance, already mentioned as being supposed to occur in Jura, does really appear to receive further confimation here, since if the central ridge of Schihallien is surrounded by mica slate, a fact of which Mr. Playfair entertains no doubt, and if this ridge is connected by any system of alternation with the sandstone of Glen Lyon, mica slate will appear to be a rock formed posteriorly to, or alternately with a rock of recomposed structure. Thus a "*primitive*" rock will be found to alternate with a "*transition*" one, an anomaly which either renders this distinction as useless as it is artificial, or compels us to modify the definition of transition rocks, or to form that total change of arrangement which I have more than once suggested with regard to the primitive and transition classes. It is, I trust, quite superfluous to say that it can have no title to the name of "granite," with which it certainly does not possess any one common feature.

Supplementary Remarks on Quartz Rock.

Having had an opportunity since I presented the foregoing memoir last year, of examining some other parts of Scotland where a similar rock occurs, I have thought it right to lay these supplementary observations before the Society, partly for the purpose of correcting the errors and supplying the defects of that communication, but principally for the sake of elucidating the history of a substance as yet but imperfectly understood, and but ill arranged, although it must already be obvious that it occupies a considerable space among the older rocks, and is entitled to rank as a principal member among them. In the former notices I have already in some measure described its general aspect and connections, although the limited extent of my researches prevented me at that time from pronouncing decisively as to the latter. I am now, from more recent observations, enabled to confirm the suppositions there made with regard to its place among the older rocks, and to add such a further description of its mineralogical character as to include many more varieties. I shall content myself with merely pointing out its geographic situation in those places which I was prevented from examining more particularly, in the hope that some future observer may direct his attention to them, and ascertain that which I have left undone.

This rock may be seen in Mar accompanying the Dee during part of its course through a country consisting of granite, followed by the usual covering of micaceous and clay slate, a country even in the Wernerian use of the term, primitive. It appears to be stratified, but of its more immediate connexion with the schistus I can say nothing, as I had no means of examining into it. Following the military road which extends from Braemar to Tomantoule it may be observed in various places, and appears to form the whole or considerable portions of the hills which, declining from the granite ridge of Cairn Gorm, accompany the courses of the Don and the Avon, and are principally constituted of different kinds of schistus. Pursuing this line northwards, it occurs more sparingly, but may still be occasionally observed, together with the schist, till the hills decline into the plain country about Fochabers. I can produce no observations through any part of this course to prove that it is a member of this class of schistose rocks ; but from its mineralogical character and general appearance, and from the resemblance which it bears to those quartz rocks whose connexions with the older schists are apparent in other places, I think future observations will confirm my supposition that it is a member of this class of rocks. A highly indurated breccia may be seen near Boharm, on the line now described, consisting of angular fragments of red and white quartz, so compacted that they do not separate from the bed on breaking the rock, but the whole gives way together, as if it were one continuous mass. The same rock now and then contains jaspers dispersed through it in the form of fragments. As I have observed similarly indurated breccias accompanying a similar quartz rock in other places, I suspect that this breccia is a portion of the same formation, bearing such a relation to this quartz rock, or compact sandstone (since it may be often better described by this appellation) as the softer and better known breccias occurring on the borders of the floetz strata do to these latter. I also suspect that greater simplicity of composition and more perfect induration will be found to be leading characters of the breccias of this class, the causes of which must be sufficiently obvious, and that portions of breccia or large grained mechanical formation, will generally be found accompanying the older schistose strata whenever these exhibit the smaller grained mechanical disposition. It is to these that the unfortunately constructed term of primitive breccias has been applied. If we could securely adopt the names of breccias and sandstones of transition, this contradiction in terms would be avoided, but if as I have already shown, and shall presently I hope more fully prove, the quartz rock uncer review does actually alternate with the rocks called primitive, it is plain that we cannot have recourse to this expedient, but must be content, if we use the term primitive, to bear with the unseemly compound. The adoption of the word primary, in lieu of primitive (a change already recommended) removes this apparent contradiction, since it is only the correlative of secondary, and involves no hypothesis with regard to the absolute æras of rock formations. But I must pass on to further matter of fact, leaving to the labours of future geologists, the actual connections and origin of these breccias, and the distinctions to be drawn among this very intricate class of rocks.

In the district of Appin the quartz rock may be observed in various parts, and although I have not been able in this place any more than in Mar, sufficiently to trace its connexion with the mica slate of the country, I have little doubt that it immediately follows, and possibly alternates with it. It may be seen not far from the castle of Bercaldine, and forms a large detached rock at Airds. Here it is of a highly indurated character, and bears the marks of a disturbed stratification. I do not think it necessary to describe the particular aspect which each rock assumes, as it most frequently happens that various modifications of it are to be met with in the same spot, and I prefer delaying the general description till I have mentioned the several places in which it is found.

The same rock occurs in the district of Arisaig. It occupies there a considerable portion of the shore, and may be traced forming low hills and interrupted projections, from the point of Arisaig, nearly to Loch Morrer. It seems here to alternate with mica slate, as I have already mentioned in another place, where I have quoted Professor Playfair's remarks on it; but possesses much less of the appearance of stratification than in the other instances which I have enumerated.

In the island of Sky it occupies a considerable space, and forms that large mountain mass which projects from the general eastern boundary of the island, so as to produce, together with the main land, the narrow passage of the *Kyle rea. Here it assumes a

* Kyle rea the smooth strait, Kyle ree the King's strait, but both are corrupt etymologies. Kyle rich, the swift strait.

character considerably different from that which it exhibits either in Jura, in Assynt, or in the other places which I have described. Its aspect is more uniform, and its texture more compact. Its fracture is rather more splintery than granular, and it rarely contains felspar, a mineral seldom absent for a long space in the generality of the quartz rock. It is here of various colours, brown, grey, yellowish, reddish, and white, but its predominant tint is a blueish grey. Its marks of stratification are obscure, yet they may, however disturbed, be traced, and its true character is I think determined by a compact breccia, which in some places may be observed separating it from the schistose rocks, the micaceous and argillaceous slate. It occurs again in Sky under another form, namely, in disrupted portions, forming the tops of low hills in the district of Slate, of a snowy aspect and compact texture, with irregular grains of felspar imbedded, and in intimate connexion with the micaceous schistus.

I have reason to think that the same rock will be found to form a large portion of that ridge of mountains which extends in a curved line to the south of Ben Nevis, so as to constitute the southern boundary of Glen Nevis; but as this conclusion is only founded on a distant observation, and on the peculiar aspect and mode of decomposition which these hills exhibit, I lay no stress on it. Yet as it actually occurs in that part of the declivity of this group which descends into Loch Eil, and is to be found constituting a considerable mass of mountain at Balahulish, I shall not be surprised if future observers assign to it a very considerable extent in this district. It is at the edges of the road between Balahulish and Fort William, that it may be conveniently examined, and it will there also be seen to alternate with a compact argillaceous schist.

On the borders of Loch Leven, and on its northern side, it is most abundant, and appears to constitute large portions of the mountains, having an evident similarity of direction and disposition, to those masses of it which form the principal parts of the mountains of Ben-na-vear on the opposite or southern side of this lake, and which I am now about to describe.

I have already had occasion to mention in a note supplementary to the account of Cruachan, that granite is found at the base of the group of mountains called Ben-na-vear, extending from Balahulish towards Glenco in one direction, and for a considerable space along the Appin road in the other. On ascending this group, the granite continues for some way. This is followed by a rock, which, although it forms here as in many other places, considerable portions of mountain masses, has scarcely received a name and an establishment in the system of rocks. It is a sort of schistose quartz; it is not graywacke, nor is it micaceous schist, though it contains grains of quartz, and mica, and clay: neither is it gneiss, although it contains grains of felspar. Previous prejudices might perhaps find it a place among either of these, according as the predominant system dictated. But the best idea of its general structure may be conveyed by saying, that if it was a flœtz rock it would be called a schistose sandstone. There is in many cases so strong an affinity between the rocks of the primary and of the secondary, or flœtz, classes, that it can scarcely lead to error, if, pursuing this analogy, I should call it a schistose quartz rock. It will in fact be found to form the same connexion between the micaceous or clay slate and the quartz rock, as the schistose sandstones which alternate with thin laminæ of clay slate do between the latest clay slates or shales and common sandstone. And thus, as in other instances, a connexion in structure and habits is established between certain rocks of the primary and of the secondary classes. In all cases the mica is disposed in lamellæ parallel to the strata or laminæ of the rock; it is never as in gneiss partially disposed in different directions, still less as in granite indifferently placed. This rock is succeeded by quartz rock in large masses. Some beds of a hard or compact schistus, of a character often approximating to hornblende slate, are also found to all appearance alternating with it, and I have already noticed in the paper above alluded to,* that granite veins are found to traverse this particular schist. The hill is, on its accessible face, so covered with soil, that no very positive evidence can easily be procured of the alternation which I suspect; and the precipitous faces are generally inaccessible, always hazardous of access. As we approach the summit of the mountain, the quartz rock becomes established to the exclusion of the schist, and it continues to the top, where it offers that aspect of complete disintegration before described under the heads of Jura and Assynt, which covers the tops of the quartz mountains with ruins, and gives them that acute apex and regularly conoidal declivity, which, as far as I have yet observed in Scotland, is sufficient even at a distance to indicate the nature of the rock of which they are composed. The laminated or stratified structure is by no means so evident in this example as in those I have before adduced from Jura, Schihallien, and Assynt; but it still bears the marks of a broken and disturbed stratification. Such being the case, and such the infinite variety of position, direction, and elevation, assumed by this rock, I think it unnecessary to enter into any details on these heads. I may only remark generally, that it stands at an angle not far deviating from

* Vide paper on Cruachan.

the vertical position, and that this angle is similar to that held by the schistus with which it is accompanied.

The composition of this rock offers through different parts of its mass different varieties, and it will not be useless to enumerate the most leading ones, merely for the purpose of proving in this, as in some of the other instances described, that many of the most remarkable mineralogical varieties exist under the same geological position. Thus the identity of the rocks as an order or division is established, and thus we may legitimately deduce those general conclusions from which its place in the system may be assigned, however in different situations its aspect and composition may vary.

It is often composed of mere grains of quartz, of an aspect extremely various, sometimes highly crystalline, though never defined by geometrical forms; sometimes shapeless and opaque. These are more or less strongly agglutinated, and are occasionally compacted to such a degree that the granular appearance is nearly lost. It contains now and then grains of felspar, imbedded in a compact quartzy basis, thus bearing a general resemblance to porphyry. These sometimes appear to be crystallized in an obscure manner, but more frequently they exhibit no regular figure. At times the felspar and quartz are so nearly equal in quantity, that the whole forms a pink-coloured granular mass, often so loose as to crumble in the hand, and in this case the grains seldom bear any mark of crystallization, but are rounded as if they had undergone attrition previously to their aggregation : occasionally, but rarely, it contains imbedded fragments of quartz. It is not often traversed by quartz veins, but wherever these occur they are much confounded at their edges with the mass of the stone. Here then, as in other instances, we see that it exhibits the ambiguous or rather double appearance of a mechanical and of a crystallized deposit, a mixture of character, which, as I have elsewhere remarked,* is not the least important difficulty which yet remains for geologists to explain.

I have reason to think that this rock will be found to occupy a very considerable space among the mountains in the vicinity of Glenco. In many places the fragments assume a dirty reddish appearance, which at a distance gives them the aspect of granite. Having in various instances made this rash conclusion myself, I think it right to suggest to those who may have an opportunity, the propriety of actually examining the rocks themselves before any opinions are formed of their nature from distant observations. From such investigations, not to be pursued without much leisure and favourable seasons, I have little doubt that the quartz rock will often be found where it was previously little suspected, and that it will be placed in a very leading situation in the system of the older rocks.

The last place which I shall now describe as affording an example of the quartz rock, is Tyndrum. The whole of this tract of country from Killin to Glenorchy in one direction, and from Luss to Loch Tulla at right angles to it, as far as it is visible from the road side, consists of mica slate, and is part of a most extensive district to all appearance formed exclusively of this rock. It is at the lead mine where the quartz rock is visible, and although I did not examine the summits of the neighbouring hills, I think it very probable that it will be found in other places among them. Its alternations with the schist are here not only perfectly satisfactory, but very frequent and numerous, and the works connected with the mine afford the greatest facility in observing them. The characters of both rocks are perfectly definite, and that of the

* Observations on Glen Tilt.

quartz rock is sufficiently various in different parts to establish its identity in the principal leading features, with the more extended masses which I have already described. It is also worthy of remark, that in some cases the same gradation which I have before noticed through schistose quartz rock takes place at the line of alternation. This instance therefore offers a proof easily inspected, and quite satisfactory, of its forming part of the same system of deposits as mica slate, and establishes its rank among the rocks of this class.

The mine of Tyndrum has long been known as a lead mine. Of the ores of this metal it affords only galena, but it also produces brown blende. It is in the quartz rock that the ore is at present found, the mine being wrought by open levels, lighted and aired from above by small shafts. Thus we see that this rock is also entitled to a place among the metalliferous ones, a circumstance which, with many others, should caution us against implicitly adopting those general rules respecting metalliferous rocks, which have been too decidedly laid down.

The nature of this paper has compelled me to chuse a geographical form of detail, which I have further preferred, that others may have an opportunity of examining the evidence on which these conclusions are grounded. But it has necessarily led to an account of the circumstances attending this rock, so detailed and divided, that it will not be useless for the purpose of mineralogical discrimination, to bring under one general view a description of all its leading varieties, and for the purpose of geological science, all the leading facts connected with its history. From the former (perhaps indispensible) details, future observers will be enabled to satisfy themselves of the truth of these fundamental remarks, and from the latter, opportunity will be afforded for a more easy generalization to those who may wish to assign its place in a system. I have selected for description all the most prominent varieties which have fallen under my notice, distinguishing their geological and geographical position whenever they were known to me, and marking at the same time the several gradations by which quartz rock appears to pass into mica slate, into clay slate, or into gray-wacke.

1. Pure white granular rock, consisting of amorphous grains of quartz, strongly agglutinated :—a perfect granular quartz. Although the grains separately taken are transparent, the mass is necessarily opaque. From Balahulish.

2. The same rock, but containing angular fragments of white felspar dispersed (although rarely) throughout it. From the same place.

3. The same rock, with extremely minute amorphous fragments of felspar in abundance. From the same place.

The rock whence these specimens were taken alternates with a very compact micaceous schistus, and the flat surfaces which have long been exposed to the weather, assume a sort of enamelled appearance, not much inferior to the polish given by the lapidary's wheel.

4. Pure white quartz, formed of semitransparent amorphous grains, but the mass has a fracture intermediate between the granular and splintery. From Sky, and alternating with micaceous schist.

5. A similar rock from Balahulish, of a pink colour, but with an aspect more harsh and dry, resembling common secondary sandstone. In the same situation.

6. Pure granular quartz in the same situation, but the grains of large size, and the fracture consequently very coarse. From Portsoy.

7. White quartz, with a fracture almost purely splintery, the granular texture being invisible to the naked eye, but sufficing to render the stone dull and opaque; alternating with micaceous schist. At Balahulish.

8. Granular quartz, of a dull aspect, in the same situation, and from the same place, with atoms of mica dispersed here and there throughout it.

9. Granular quartz disposed in parallel stripes, alternately white and brown, but containing no foreign substance. From Balahulish, and in the same situation.

10. The same with pyrites, and in the same situation.

11. Granular quartz, deeply stained by iron, from Assynt, of various colours, yellow, red, and brown, but the grains of quartz transparent; reposing on gneiss.

12. Granular quartz of a pale blue colour, containing pyrites; alternating with talc slate. Near Inverara.

13. Granular rock, formed of large grains of quartz of various dark colours, and generally transparent. It contains here and there rounded and distinct grains of red opaque quartz, and of glassy felspar. From Jura.

14. Dark-gray rock, of a granular splintery fracture, with pyrites. From the same place.

15. Dark greenish-gray, of a similar aspect, without pyrites, extremely compact. From Sky; following mica slate.

16. The same, of a darker colour, and from the same place. The influence of the weather whitens it, detecting what the magnifying glass cannot, the existence of felspar as an ingredient, and which is probably the glassy variety, since it cannot be distinguished

from the transparent quartz grains with which it is intimately united in the fresh rock.

17. The same rock in point of external aspect, but evidently formed of highly compacted and rounded grains of many different colours. From the same place.

18. Brown quartz rock, of which the fracture is so little granular that it almost approaches to common quartz ; semitransparent. From the mountains of Mar, Angus, and elsewhere, alternating with micaceous schistus.

19. The same rock, in the same situations, of various shades of red.

20. An almost equal granular mixture of pure transparent quartz, and snow-white felspar, the grains amorphous. From Arisaig and Balahulish, with micaceous schistus.

21. The same, but with fragments of felspar, bearing obscure marks of crystallization. From the latter place.

22. Waxy and perfectly compact quartz, having a porphyritic aspect from imbedded fragments of felspar ; accompanying the same rocks.

23. White granular quartz rock of a moderately fine grain, containing at the same time large angular pieces of quartz, of a diameter from half an inch to many inches. In the same series at Balahulish.

24. White granular rock consisting of felspar and quartz traversed by veins of pure white granular quartz, resembling in colour and texture the finest sugar. From Jura and elsewhere.

25. Distinctly rounded grains of the purest transparent quartz, imbedded in a mass of very fine grained white quartz. From the Cape of Good Hope.

26. An uniform mixture of grains of transparent white quartz and opaque reddish felspar, containing rounded pebbles and fragments

of purple and of white quartz, the pebbles being from half an inch to two inches in diameter. In Jura, forming part of the series of the purer quartz rock.

27. A brecciated mass of felspar and quartz of various colours, compacted by a cement of transparent quartz, forming part of the series at Balahulish.

28. Specimens from Arisaig, from Assynt, Mar, Balahulish, Airds, Sky, Schihallien, and numerous other places, which consist of variable mixtures of reddish felspar, and transparent quartz, sometimes appearing to be nearly all quartz, and at others to contain a large proportion of felspar. The grains are of various dimensions, and the texture of the stone is consequently various. At times it has the aspect of a fine reddish sandstone, at others of a coarse grit; and where the grains are very unequal in dimensions it resembles a breccia. The grains have never a defined form.

29. A rock consisting of narrow and alternating parallel layers, of fine and coarse granular quartz. Large grains of felspar are found in the coarse layer, but none at all in the fine one. From Balahulish.

30. A scarcely coherent combination of large grains of quartz and felspar, the interstices either empty or filled with clay. Part of the series at Balahulish.

31. Compact extremely fine granular splintery quartz, alternating in thin layers with clay slate. From Cowal.

32. Fine sandstones, not to be distinguished from the flœtz sandstones, and like many of them striped in endless alternations by black clay. From the series of Balahulish. These belong to that quartz rock which alternates with clay slate, and show the transitions between those two substances.

33. Fine grained granular quartz, alternating with layers of

parallel mica, so thin as not to be discovered in the cross fracture. From Fassafern, Balahulish and Tyndrum.

34. The same rock, but the layers of mica more conspicuous and undulating. From Balahulish.

35. The same passing into mere mica slate. From the series at Balahulish and Tyndrum. These demonstrate the alternation of the quartz rock with mica slate.

36. A large grained breccia consisting of fragments of quartz cemented by a mass of earthy white felspar, approaching to porcelain clay. From Jura.

37. A rock consisting of felspar and granular quartz, with here and there an atom of blue slaty clay interspersed among the grains. From Jura.

38. Various specimens of the same, with the clay slate increasing.

39. The same approaching still nearer to graywacke, with a basis of clay slate, and ultimately terminating in it. These two from Jura.

These specimens show the transition into common graywacke slate.

40. The same composition of rock, but in which mica slate holds the place of clay slate.

Different specimens of this variety demonstrate the passage of quartz rock into that sort of graywacke which I have described under the head of Aberfoyle. From Jura.

41. The same rocks passing by insensible degrees into a conglomerate, which will by some be ranked with common graywacke. From the same place.

From a comparison of the several characters under which this rock appears in the same place, from the similarity of these characters or of a majority of them in the different situations in which it occurs, there need be no hesitation in concluding that quartz rock wherever occurring is generically the same, and that it differs no more from itself than the numerous varieties of gneiss, of mica slate, or of graywacke are found to do. It ought therefore to be designated in a geological system by one general name, since, as the designations of rocks are intended for the purposes of geology, rather than of mineralogy, it is preferable that one common term should be applied to the rock in question, than that the several varieties should each receive a separate one, a circumstance tending as much to confuse geological reasonings, as to render them tedious and intricate. It has already received various names, out of which it would be desirable to agree on one. It has been called granular quartz, transition sandstone, quartzose graywacke, and quartz rock. The first of these sufficiently expresses the character of one of its varieties ; but its particularity excluding those modifications which are not granular, as well as those which contain felspar, is not well adapted for the purposes of geological description. Could we prove that it was in every case a rock of transition, and that the theory which the term transition implies was well founded, the name of transition sandstone would perhaps be the most applicable. But as I have ascertained that it alternates at times with rocks, which the system here alluded to calls primitive, and as it is at all times desirable to keep clear of those terms which involve an hypothesis, I think we are bound to reject this name. The same argument is valid against the appellation of quartzose graywacke, a term in other respects perfectly inapplicable, since the very definition of graywacke decidedly excludes it; and there can be no greater evil than to confound under one name, substances of different qualities, particularly when that name itself, from its connection with an hypothesis, tends to blind our judgment and pervert our reasonings. I should therefore suggest the superior propriety of the term quartzy or quartz rock, a term involving no hypothesis, and which, at the same time that it is sufficiently general to include all the varieties which consist of mere quartz, does not exclude those which contain a mixture of other ingredients, more than the terms sandstone or limestone exclude the various bodies which so often are mixed with, or constitute an integrant part of them. When more particular description is required, a term so general admits of being easily combined or modified.

We have now to enquire into the rank which this rock bears in the generally received arrangement, and into its claims on a place in either of the classes of chemically crystallized or mechanically deposited rocks, or of that which is conceived to be a mixture of both; to use language more hypothetical, we must try to assign it a situation in the primitive, transition, or floetz divisions. It appears that it is found, as at Tyndrum and Loch Leven, alternating with micaceous schist, and in many other places with what is called primitive clay slate. Thus its claim to a rank among the first division of rocks is established. Its connection with graywacke in Jura, equally establishes its claim to a place among those rocks which are assigned to the second division. It is thus, like clay slate, a member of both these formations. I have already shown, that at Balahulish, as well as in Jura and in Assynt, the quartz rock contains mechanical deposits, from which it must follow that the existence of a mechanical deposit is not a decisive character for the rocks of transition, since a rock of which one of the characteristic circumstances is mechanical arrangement, is found to exist among the rocks called primitive. As I have also shown in describing the country about Aberfoyle, that a gradation from mica slate to graywacke takes place by insensible degrees, I think we may conclude that no valid distinction, nor any constancy of character, such as ought to constitute a class, is to be found in the rocks of *transition*; and that it would be preferable to return to the ancient division of primary and secondary, as far at least as relates to those rocks which bear marks, however obscure, of stratification. It will be a separate consideration by what means we can divide those of the former class which contain organic remains, from those which are without them; a distinction, perhaps not less requisite in the one than in the other of these two leading classes, since, however many members of the floetz or secondary division may be characterized by the existence of these remains, a certain set are as invariably free from them.

It is perhaps beyond the bounds of the present notice, to suggest the propriety of separating the unstratified rocks, such as granite, porphyry, and trap, from this two-fold arrangement. Should such a measure be ultimately adopted, it will be further necessary to consider how far any one of the several unstratified rocks is peculiar to the one set of stratified ones, and how far it is common to both. A more accurate knowledge of the various rocks designated under the loose name of porphyry, will be particularly requisite to the forming of this arrangement.

XX. *Notice relative to the Geology of the Coast of Labrador.*

By the Rev. Mr. Steinhauer.

THE coast of Labrador is a part of the British territories so little known, and possessing so few inducements to attract the visits of strangers, that every fragment of information concerning it may be esteemed in some degree valuable. This is the only excuse for offering the following observations in their present very imperfect state.

The only English accounts of this country, as yet published, are the memoir of Lieut. (afterwards Sir Roger) Curtis, and Mr. Cartwright's journal. The first-mentioned gentleman reconnoitred the coast from the Straits of Belle-Isle to lat. 58°, 10′, (according to Arrowsmith's chart, 57° 25′,) in the year 1773, by command of Governor Schuldham. His account is inserted in the Philosophical Transactions. The latter person does not appear to have gone farther north than lat. 54°, and his observations refer to little farther than the fishery and peltry trade. At the request of the British government, and particularly of Sir Hugh Palliser, then governor of Newfoundland, the United Brethren made several voyages of discovery to this coast; and in 1772, formed a settlement in lat. 56° 38′, (56° 24′ Arrowsm.) called *Nain;* and subsequently two others, *Okkak* and *Hopedale*, in lat. 58° 43′, and 55° 36′. Hence they have made several excursions, and last year doubled Cape *Chudleigh*, in lat. 60° 20′, and descended on the opposite or western side of the promontory as far as lat. 58° 36′.

The missionaries, assiduously occupied with the great aim for which they are sent, may be supposed to have but little time for objects of mere science; they have however not been neglectful of the opportunities their stations afforded, but have improved them as far as their abilities allowed. They have kept meteorological tables of the barometrical and thermometrical variations,* a tolerably complete flora has been collected; they have from time to time sent specimens of the minerals of the country; and their diaries and verbal accounts furnish some idea at least of the principal mountains on the coast. It is to be regretted that their observations are of such a nature as to throw little light on the geology of the country; even the specimens sent have not always their habitats affixed, or get confounded on board of the vessel. The general aspect of the country is else such as to promise interesting results, and the examination of the different strata is not liable to those obstructions from the enveloping mantle of vegetation and alluvial mould which so often baffle all research in our countries. According to the descriptions of those who have had an opportunity of contemplating this inhospitable region, it consists almost entirely of barren rock, towering in craggy eminences, on which even the hardy lichen in vain endeavours to fix a habitation; for moisture enters the rock with its fibres; the intense cold of winter congeals that moisture, and the summer's thaw precipitates the loosened fragment with its tenant to

* In *Nain* the extremities of cold and heat in the year Nov. 1, 1772, to Nov. 1, 1773, were—Jan. 16, 8 h. A.M. 42 under Farenheit's O, and Aug. 2, 2 h. P.M. 86. From Jan. 11 to Jan. 27, the thermometer was never above Farenheit's O.

the foot. These fragments, mouldering into sand, afford in some places support to a few species of pines, and the annual decomposition of their leaves stains this earth to the depth of a few inches with a blackish hue. In other spots where the thawing snow occasions an accumulation of water, *sphagna* and other mosses form a species of turf, and conceal the barrenness of the land; but every where the plucking up a tuft of vegetation, or removing the withered leaves, discovers either the bare rock or a bright silicious sand. In several parts of the country the rocks are intersected by chasms running generally in a right line to a considerable distance, as if intended to be the receptacles of future veins; the floor, as I am informed, is composed of a different species of stone from the sides, and generally of a lighter colour; but I could not, from the description, ascertain whether it was calcareous or not. These clefts when covered with snow in the winter, sometimes prove dangerous pitfalls to the unwary wanderer, who does not know how to avoid them by the line of bushes (*vaccinia*, *ledum*, *&c.*) which fringe their margin. Indeed the narrow passages which divide the coast into numberless islands, almost seem to be similar chasms occupied by the sea, few, if any, of these islands being alluvial, but high barren rocks, appearing from the sea like continuous land.

The *highest mountains* seem to extend along the eastern coast; the names and situations of the principal, known to the missionaries, are

The *Nachwak* chain, about lat. 59°.

The insulated mountain, *Tupperlik*, (the tent) lat. 58° 15′.

The *Kaumayok* chain terminating in the high island of Cape *Mugford* or *Grimmington*, lat. 58°.

The high land of *Kiglapyed*, in lat 57°.

The *Mealy mountains* laid down on Lane's survey of the coast of

Labrador, in lat. 53° 50′, and said to be never free from snow ; they have not been visited by the missionaries, who now seldom go far to the south of Hopedale.

With respect to their actual height little can be said with certainty, but as Mount Thoresby, on an island south of Kiglapyed was ascertained by the officers of H.M.S. Medusa and Thalia, to be 2733 feet, and the Kiglapyed is evidently higher, yet inferior to the Kaumayok and Nachwak heights, the latter cannot be assumed at less than 3000 feet. This supposition gains additional probability, from the circumstance that the Kaumayok has been seen by Capt. Frazier,* at a distance of upwards of 30 leagues from land. The mountains to the west of Cape Chudleigh are much lower, and, according to the accounts of the missionaries, of a *different nature;* but wherein the difference consists we are unable to determine.

It would, doubtless, be highly interesting to ascertain the constituent strata of these elevations ; but the attention of the missionaries being more directed to mineralogical than geological specimens, and being apt to esteem nothing worth notice, but what, by form or colour attracted notice, we have little more than hints to guide our suppositions.

From the islands near Cape Chudleigh we have received specimens cf large-grained pale *granite*, with garnets. The island of Ammitok (about lat. 59° 20′) is described as consisting almost entirely of a crumbling granite, sometimes mixed with hornblende. The mountains of Nachwak, about Nachwak bay, furnish considerable quantities of *lapis ollaris*, generally of the grey kind, (of which a specimen is sent) but sometimes of the semi-transparent

* The master of the ship annually sent with provisions to the missionaries.

green variety. The missionaries describe the southern part of this chain, as exhibiting a very singular appearance towards the sea, being composed of alternate layers of black and white rock in a vertical position, which makes the cliffs seem striped; the black strata are about 5 feet in thickness, the white double that breadth. Nulletartok bay, still farther south, and probably near the extremity of the same chain, has been called *Slate Bay*, from a stratum of slate which appears there a little above high-water mark; from this stratum the travellers write, that an acrid liquid, of a strong sulphureous smell, exudes, which seems to indicate an impregnation with sulphuric acid. Below high-water mark, in the same bay, they noticed a stratum, which they describe as resembling cast iron, with a glossy, somewhat reddish, surface, and extremely hard, (qu. a haematitic iron ore?) The north side of the Kaumayok mountains consists of a white stone, with black or grey veins, resembling statuary marble, but very hard. Of the productions of the Kiglapyed we have no account, but to the south of this chain the district commences, where the Labrador felspar is found. This stone was first distinguished by the late Rev. B. Latrobe,* among a number of specimens sent to him; it occurs not only in pebbles on the shore, but in spots in the rocks in the neighbourhood of Nain, and particularly near a lagoon, about 50 or 60 miles inland, in which Nain north river terminates. Its colours darting through the limpid crystal of the lake, and flashing from the cliffs more especially when moistened by a shower of rain, changing continually with every alteration in the position of the boat, are described as almost realizing a scene in fairy land. The same district produces

* President of the Society for the furtherance of the Gospel established by the Brethren.

also the Labrador hornblende, *(Hyperstène)* and the white stone striped with green, which seems to constitute a rock on an island near Nain, and was first noticed by the Rev. C. J. Latrobe, among other fragments, which induced him to cause large fragments to be broken off and brought over.

One of the mountains in the vicinity of Nain, as well as several others in different parts of the coast, exhibits a species of Mam-tor, continually crumbling away and shivering down into the valley below; a splinter of this rock is sent for the inspection of the Society.

The island of Ukusiksalik or freestone island, has derived its name from the quantities of lapis ollaris found there. It is probably the most southern place on the coast where this mineral occurs, as the missionaries, who first visited the Eskimos in Chateau Bay, in the Straits of Belle Isle, were told by them that they procured the stone of which their lamps, pots, &c. were made from this island.

At Hopedale the secondary limestone seems to come in; at least we have received from this place fragments of reddish carbonate of lime, calcareous spar, and schiefer spar. Mr. Latrobe also possesses a madrepore, said to have been found there. It is remarkable that the river abounds in fragments of stone, worn into the most fantastic shapes, in which the imagination without great exertion may trace the rude resemblance of birds, crocodiles, &c. They sometimes form rings six or eight inches in diameter, and three quarters of an inch thick. Their great abundance precludes the possibility of their being the work of art.

With respect to the land, west of Cape Chudleigh, as it has been but once visited, we cannot expect to learn much about it. The mountains of *Torngarsuit*, (the evil spirit) in lat. 60°, are described as rugged, barren, and black, and containing a huge cavern which the heathen Eskimos fable to be the habitation of the devil. The rocks farther north are light-coloured, but there appear to be no mountains of considerable height on this part of the coast which is called *Ungava.* On almost every part of it fragments of a red jasper, impregnated with iron, are frequent, and in some places haematites and cubical pyrites. It may be worth remark, that the tides rise here no less than 40 to 50 feet, while they seldom exceed 8 or 10 on the eastern coast. The current sets from west to east round Cape Chudleigh.

The specimens of rocks from Labrador, which Mr. Latrobe has desired me to select for the Society, will enable them to form any further conjectures with respect to the geology of this country far better than I should be able to do it, and I shall esteem myself happy if future opportunities enable me to discover any thing which may be able to throw a more direct light upon the subject.

The specimens marked merely *Labrador*, are from one or other of the three settlements, consequently found between lat. 55° 30′, and 57° 40′.

XXI. *Memoranda relative to Clovelly, North Devon.*

By the Rev. J. J. Conybeare, Member of the Geological Society.

In a Letter addressed to G. B. Greenough, Esq. V. Pr. G. S.

My Dear Sir,

If either the enclosed memoranda relative to the neighbourhood of Clovelly, or the drawings which accompany them possess any interest, they can derive it only from the consideration that the geological features of that remarkable spot do not hitherto appear to have attracted the attention of any person engaged in those studies which it is the object of our Society to promote. The former, though, I trust accurate, are, I fear, extremely scanty. The latter I can only offer as faithfully copied from sketches made upon the spot, they will furnish their own apology by shewing at once that they are the work of one who is uninstructed and almost entirely unpractised in that art.

The small Fishing Town of Clovelly is situated in a narrow and precipitous ravine on the north coast of Devon, about 22 miles to the westward of Ilfracombe, and has attracted some notice from the singularly picturesque scenery of itself and its more immediate environs, the general character of which much resembles that of Linton, upon the same coast, so frequently described by modern tourists.

Having understood that, in addition to this recommendation, the cliffs near the town presented very ample and numerous sections of the stratified rock of the country; Mr. Buckland and myself were induced to visit it in the course of an excursion which we made in the west during last summer.

The best access to the town from the Hartland road is by a private carriage way which has been cut through the grounds of Sir James Hamlyn. This not only commands several advantageous views of the lofty and well wooded ravine along the declivity of which it winds, but offers in many places, where the rock has been cut away for the purpose of levelling the road, striking instances of that remarkable configuration of the strata, which is said to be characteristic of the grauwacke formation. To that class all the rocks of this neighbourhood may probably be referred. The principal varieties are those known throughout Devonshire by the appellation of *dunstone* and *shillat*; the former answers pretty accurately to the description usually given by mineralogists of that species of grauwacke in which the fragments, supposed to be cemented together by the intervention of a paste resembling the matter of clay slate, are too small to be discerned even by the aid of a considerable magnifier. The latter alternates with the former and is evidently the finer grauwacke slate of the same nomenclature. Of these rocks the coast between Clovelly presents the most magnificent and interesting sections which we met with in the course of our tour. Both varieties sometimes alternating in distinct and well defined strata, sometimes appearing to graduate into each other, and the compact species assuming the external configuration of greenstone or serpentine. The strata inclined in every direction and describing the most capricious and picturesque forms, both curved and angular, open an abundant field of instruction to the geologist, while they present difficulties of which neither the theory of original deposition on an unequal surface, or of subsequent dislocation, appear to promise any plausible solution.*

The average height of the cliffs, as far as we could judge by the eye, is 130 or 140 feet; they are traversed in many places by steep ravines running from north to south, and numerous outlying masses of rock shew themselves above the sea at a small distance from low-water mark, a character uniformly presented by the stratified rocks along the whole of the Northern coast.

In some parts the compact grauwacke was wanting for a considerable distance, in such cases the forms which the slate had assumed were rather angular than curvilinear. In the sections of those which have been called saddle-shaped strata, we observed usually that the dip was more precipitous on the western side. In neither variety of the rock could we discover any traces of organic remains, nor could we perceive any imbedded fragments that should indicate their having been formed from the *debris* of an earlier rock. The strata are traversed by numerous veins of opaque white quartz, but no appearances of any other mineral substances occurred.

The Drawings annexed, (Pl. 33 and 34,) indifferently executed as

* Professor Jameson (Syst. of Min. vol. 3.) has ascribed these appearances to crystallization. As we are always accustomed to regard terms of science as retaining (where the contrary is not expressly stated) the precise sense in which they have hitherto been uniformly received, the use of this expression is perhaps not strictly correct. The external appearance of these rocks is certainly not that of a mass of crystallized matter; and that the phenomenon itself is not invariably connected with the process of crystallization is evident from the consideration that those rocks which are the most highly crystalline in their texture are the most free from these singular configurations. That these appearances, however, may have been effected by a process of Nature, somewhat analogous to crystallization, and depending possibly upon the same remoter causes, is perhaps the most satisfactory hypothesis that has hitherto been offered on the subject, and such I apprehend to be the opinion of the school of Werner, though somewhat obscured by the adoption of a term implying identity of operation, in a case where the utmost which can be fairly assumed to exist, appears to be a striking analogy.

they are, will perhaps convey a clearer notion of the singular configuration of these rocks than could be done by words alone. With the exception of one, which gives a faithful resemblance of some remarkable curvatures in the grauwacke of Hartland Point, the whole of the subjects are selected from those which occurred within the first four miles of our walk from Clovelly westward.

Although these singular contortions are not entirely confined to the dunstone and shillat of Devonshire, they yet occur much more constantly in that rock than in the metalliferous schist of Cornwall. In travelling westward we appeared to lose them gradually. At Bosscastle where the rock evidently approaches nearer to the character of killas, (as it is termed by the miner) they still appear pretty frequently: at St. Agnes they are much rarer and less capricious.

It is possible that more accurate and minute researches may carry the subdivision of the stratified rocks of this country much further than the present state of our knowledge appears to authorize; but I cannot think that, even with the limited information which we already possess on this subject, it would be assuming too much to establish a line of separation between the rock, which under the provincial names, already mentioned, of dunstone and shillat covers so large a portion of the North of Devon, and that metalliferous slate which lying immediately upon the granite of Dartmoor and Cornwall forms the most considerable portion of the mining tract in both counties. *

The former of these, besides the peculiarities already noticed, is

* I would wish to be understood as speaking exclusively of the metalliferous slate. That which alternates with limestone at Vesyan, at Padstow, (where it is accompanied by greenstone) and some other spots in Cornwall, will probably be regarded as belonging to a distinct formation.

destitute of metallic veins. It alternates with transition limestone, and where it does so, occasionally contains organic remains. It alternates also, in one instance at least, with large beds of a species of culm. Its veins contain few or no extraneous substances besides common quartz and, though less frequently, calcareous spar. *

The latter (the Killas of Cornwall) has generally the silky character ascribed to clay slate.† It is traversed almost throughout its whole extent by frequent veins, or rather dykes, of a porphyritic rock, which forms one variety of the Elvan of the Cornish miners, and which does not occur either in the dunstone or shillat. It has been found to contain at St. Agnes, the topaz, and in various places the tourmalin and the garnet: the veins are frequently occupied by chlorite, by mica, and by crystallized felspar. A considerable part of the tin of Cornwall is obtained from the killas, and the grey ore of cobalt has repeatedly been found in it. All these minerals have usually been considered as characteristic of the earlier rocks, and none of them are, I believe, stated by the writers of our most esteemed mineralogical systems to occur in that to which they assign the name of grauwacke.‡

It is not without the greatest diffidence in my own knowledge of the subject and powers of observation that I venture to dissent, even on a mere point of nomenclature, from the opinion of my able and experienced friend Dr. Berger. I cannot however but conceive that

* In the neighbourhood of Bideford, a little to the west of Ilfracombe, the rock is said to be much traversed by this mineral.

† May it not be added that its siliceous varieties are of a texture much finer and more compact than that of Dunstone?

‡ The following substances also which appear (although less positively) to be restricted to primitive formations by the school of Werner, occur in the killas; wolfram, native silver, horn silver, schiefer spar, actinolite. I believe that the chiastolite has also been found in it.

the marked difference between the two great varieties, which appear to include by far the larger part of the stratified rocks occurring in the west of England, is such, as to render it by no means desirable that they should both be designated by the common name of grauwacke;* a name perhaps the more liable to misapplication as it is somewhat indefinite.

* If the reasons which I have ventured to suggest for the propriety of considering the dunstone and shillat as of a formation distinct from that of the killas be not entirely void of foundation, it is perhaps the more desirable that the attention of geologists should be called to the examination of the subject, as it is understood that a large and respectable body of mineralogists are disposed to apply the name of killas to those stratified rocks in the northern part of Great Britain, which have hitherto been considered by the most accurate observers as indisputably belonging to the grauwacke formation. Is it not possible that the frequent, for I apprehend we are scarcely yet entitled to say the *total* absence of gneiss and mica slate in the mountain groups of Cornwall may have contributed to give rise to this opinion? This character however they appear to possess in common with the Hartz, in which Professor Jameson states the clay slate to rest immediately upon the granite.

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XXII. *On Staffa.*

By J. MAC CULLOCH, M.D. F.L.S. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich. V. Pr. Geol. Soc.

IF the "Description and Natural History" of Staffa, by Faujas de St. Fond, or the various other descriptions which have been published of this island by naturalists and by tourists, had exhausted the subject, I should have forborn to have troubled the Society with any remarks on a place which ought now to be well known.

But a visit to this celebrated island having given me an opportunity of remarking a circumstance before unnoticed, and of some importance in its natural history, I think it my duty to lay it before the Society. In so doing, I find it difficult to avoid entering rather minutely into the general description of the island, particularly since a second examination, besides confirming the remarkable fact I at first noticed, has enabled me to investigate its structure more completely. I shall doubtless still leave something to be corrected by those who may come after me. A multiplicity of objects pressing at once for regard, a visit always necessarily hurried from the impossibility of remaining long on the island, a boisterous sea, and a stormy atmosphere, are hostile to that accuracy of observation which may preclude future corrections.

The circumference of Staffa is estimated at about two miles. It forms a sort of table land of an irregular surface, bounded on all sides by perpendicular cliffs, varying in altitude and broken into numerous recesses and promontories.

It is intersected by one deep cut, scarcely to be called a valley, which divides the higher and more celebrated columnar part from the remainder of the island. At the highest tides this more remarkably columnar part which forms its southwestern side, appears to terminate almost abruptly in the water, but the retiring tide shows a causeway of broken columns forming a sort of beach at its foot. Round the other sides of the island there is also a beach of varying breadth, consisting of detached fragments, and of rocks jutting out into the sea in many irregular directions. This beach, when the weather is perfectly calm, and the swell off the shore, will, under due precautions, afford landing in various places, but it is on the eastern side that the most numerous landing places occur. Various narrow creeks sheltered by the island itself from the predominant western swell, admit of easy access in moderate weather, provided the wind is in any direction from SW. to NW. and for the encouragement of the mineralogist, who may be terrified at the exaggerated reports of this difficulty, I can assure him that I have landed on Staffa when the vessels that navigate this sea have had their sails reefed, and the boatmen of Iona and Ulva have called it impracticable. The love of the marvellous has conferred on Staffa a terrific reputation, which a greater resort has discovered to be somewhat akin to that of Scylla and Charybdis.

It is easy to perceive from the southward, that with this flat disposition of its surface, and notwithstanding its irregularities, Staffa possesses a gentle inclination towards the N.E. although no opportunity is afforded for ascertaining the precise dip. It is not of importance to ascertain it, nor can it amount to more than 5 or 6 deg. of variation from the horizontal plane.

The highest of the perpendicular faces which bound it, rise about 60 or 70 feet above the high water mark, and these are on the south-western side, where the most remarkable columns and where the great caves exist.

The greatest elevation of the island cannot be more than 120 feet above the level of the sea. There are no sunk rocks round it, but the water deepens rapidly from the shore, and admits of large vessels coasting it close at hand, provided they have a leading wind.

There is a soil of considerable depth on the surface, and it is covered with herbage.

It is almost superfluous to say that the whole island consists of a mass of basalt. I have indeed been told, that a sandstone bed has been seen at low water on the southwestern side, but I had not an opportunity of observing it. This is the part of the island, where, if in any place, it should, from the inclination of the strata, be perceived, and there is no reason to doubt the assertion, as we find most of the trap rocks of the Western Islands lying on beds of sandstone. It is equally superfluous to describe the basalt, since specimens of it are in every one's possession. It may be sufficient to remark, that its texture is more compact, more crystalline, and less earthy than that of basalt in general, and that it is at the same time less homogeneous, less black, more fragile, and more sonorous. But it would be idle to attempt to apply different terms to the endless varieties of the rocks of this tribe.

This basalt exhibits two modifications, the columnar, so often described, and the amorphous which is generally more or less amygdaloidal, containing imbedded zeolites of different sorts. I saw no examples of basaltic breccia, or of trap tuff, as it is improperly called.

It is in the amorphous basalt that the zeolites are most abundant. The nodules vary from the size of a pea to that of an hen's egg and upwards, and generally exhibit specimens of radiated mesotype and of analcime. The cubical zeolites (chabasite) are of rare occurrence, and the mesotype is seldom granular, and never, as far as I saw, capillary. The lamellar variety of stilbite, is occasionally found filling the intervals of approximate columns. I did not observe any zeolites in the larger and more perfect columns, but in the smaller and more irregular ones they occur, though rarely.

If we were to view the island only from the southwestern side, and at half tide, we should conclude that it has been formed of three distinct deposits, or beds of basalt. Of these the lowermost appears in some places amorphous, but it is not easy to see enough of it to judge whether it actually forms a continuous bed. It is only from the analogy of Canna, and the other basaltic islands of this sea, that we should be tempted to generalize this conclusion.

The next bed, is that which is divided into those large columns which form the most conspicuous feature of Staffa, and it varies from 30 to 50 feet in thickness. The upper one appears at a distance to be an uniform mass of amorphous basalt, but on a nearer inspection it is found to consist of small columns, laid and entangled in every possible direction, often horizontal, and generally curved. It is this bed which forms the ponderous cap (as it is called) which crowns the summit of the grand *façade*.

Although the great columnar bed occupies but a small portion of the whole exterior face of the island, the columnar form is perhaps predominant throughout the whole. Yet it would be equally difficult, as useless, to attempt to determine its proportion to the amorphous part where they are irregularly mixed, as they are at the northern and eastern sides. On these sides also the division into distinct beds such as I have described above, is by no means easy to trace, and possibly it does not exist.

To those who have seen the beautifully regular columns of the Giant's Causeway, those of Staffa will appear rude and comparatively shapeless. They no where exhibit that accuracy of design which is so conspicuous in the former, and are rarely seen of any considerable length without some incurvation. But their thickness is much greater, since they often attain a diameter of four feet. They vary perpetually in the number of their angles, the pentagonal and hexagonal being the most common, and those of an inferior number of angles being less common than those of a superior. Their joints are very irregularly placed, and are frequently wanting through a considerable length. When separated, the touching surfaces are either flat, or marked by a slight respective concavity and convexity. In many places, and most conspicuously in the great cave, the angles of the upper joint are considerably and obliquely truncated at the point of contact with the lower one. But I did not perceive any instance where a corresponding projection of the end of the inferior angle rose to cover the truncation, a circumstance of such frequent occurrence at the Giant's Causeway. I may add, that the articulated columns are most remarkable in the great cave, and that the straightest columns generally exhibit the most frequent articulations. The curved columns visible at the cave called the Clamshell cave, extend for 40 or 50 feet without a joint.

The disposition of the variously curved columns above this small cave, is perhaps one of the most striking features of the whole island. But it will be time enough to speculate on the formation of a curved basaltic column, when we have something rational to offer on that of a straight one.

A very extraordinary aggregation of columns lies off this cave, forming a conical detached rock, corruptly called Boo sha la. The Gaelic name Buachaille (Βουκόλος?) the herdsman, is commonly applied to conspicuous single rocks all over the country. This rock consists of variously inclined columns resting against each other, and meeting till they form a conical body, which appears to repose on a bed of curved and horizontal columns.

It is superfluous to attempt a description of the great cave. The language of wonder has already been exhausted on it, and that of simple description must fail in an attempt where hyperbole has done its utmost. I may however remark, that its dimensions appear to have been over-rated, in consequence of the mode of measurement adopted, and that the drawings of it which have been engraved, give it an aspect of geometrical regularity which it is far from possessing. Its superiority in point of effect to the greatest efforts of architecture, might admit of dispute if there were any disputing about feelings. Another cave occurs at a short distance westward, of inferior dimensions, and inaccessible unless when it can be entered in a boat, an event requiring a combination of circumstances of no very common occurrence at Staffa. Large fissures are seen above this cave, with an incipient detachment of considerable masses, threatening a ruin which is perhaps not far distant. Beyond this there is still another cave which appears to pass through the promontory in which it lies, but equally or even more difficult of access, and still involved in uncertainty. Many other caves of less note are to be seen in various parts of the cliff around the island, into which the sea breaks with a noise resembling that of heavy and distant ordnance.

In a letter transmitted last year to the Secretary of this Society, I took notice of a fact of considerable importance in the natural history of this island, which had before escaped the remarks of visitors. This is, the occurrence of a bed of alluvial matter on some parts of its surface, containing fragments of the older rocks. It is most easily seen at that side of the island which faces Iona, and on the summit of the cliffs of a semicircular bay opening in that direction. The bed is here broken at the edge of the cliff, so as to expose its whole thickness for a considerable extent. But the same appearance may also be observed immediately above the ordinary landing place, where the bed has also been broken. The stones which it contains are all rounded, and of various, often considerable dimensions, and they exhibit specimens of granite, gneiss, micaceous schistus, quartz, and red sandstone. Together with these, are some rolled pieces of basalt.

Here then is a circumstance in the mineral history of Staffa, adventitious it is true, but involving difficulties of no small importance. If we cast our eyes on the map, (Pl. 35.) we shall perceive that it is embayed in a large sinuosity, formed in the island of Mull, and nearly enclosed on the opposite side by Iona, and the Treshanish islands. Beyond the latter, a second line is drawn by Tirey, and Coll; while to the north, but at a greater distance, are placed the islands of Muck, Rum, Egg, Canna, and Sky. The whole island of Mull, with the exception of the Ross, is of a trap formation, containing however some partial tracts of sandstone and other rocks which I need not notice. The islands of Ulva and the Treshanish, with their dependent rocks, are also of trap formation. So are the islands which lie to the north, and which I have enumerated above. Iona however, together with Coll and Tirey, consists principally of gneiss and mica slate traversed by granite veins, rocks which also form the chief parts of the coasts of Lorn, Appin, Morven, and Ardnamurchan.

It is to the former then, that we must look for the origin of the rolled stones which cover Staffa, if, limiting the great operations of nature by our own narrow views, and the ages which have contributed to change the face of the globe by our own short span, we are led to seek for that solution which may appear the least difficult. Even then, we must admit that Staffa has formed part of one continuous land with the islands of Coll, Tirey, and Mull, since no transportation could have been effected without the existence at some period of a continuous declivity between them.

The language which this circumstance speaks, is not obscure, and the nature of these changes allows of little dispute. If we admit this obliteration of so large a portion of solid land, and consider that a deep sea now rolls above the foundations of former mountains, we have no further difficulties to obstruct us in accounting for the numerous and distant accumulations of transported materials which occur over the whole surface of the earth. The same power, whatever it was, that hollowed the great sinuosity of Mull, might well remove the solid matter that once filled the valleys which now separate Mont Blanc from the ridge of Jura.

But if appalled at the supposed magnitude of those changes, and at the period of time which must have elapsed to complete them, we suppose that the island of Staffa was elevated from the bottom of the sea in its present detached form, and retaining on its summit a portion of the bed of loose matter deposited under the present waters, another order of phenomena crowds on us, no less important, and involving circumstances almost equally repugnant to the visible operations of nature.

The appearances are perhaps insufficient to enable us to decide between two difficulties of equal magnitude, nor is it here necessary to enter further on that question. I may also leave it to those who have engaged more deeply in such investigations, to determine whether in the supposition of the first of these causes, whether the wasting of the land has arisen from the gradual action of natural operations, or the more violent efforts of an occasional destroying force. It is my humble task to point out a fact, as a contribution to that mass of accumulating information on which a consolidated fabric may at some future time be erected. Yet the idle spectator or enthusiastic lover of Nature who shall hereafter view this interesting spot, may, when he contemplates these grand revolutions, learn to wonder less at the efforts of that power which has hollowed the cave of Fingal, and submerged in the depths of the ocean those columns which seemed destined for eternity.

XXIII. *On Vegetable remains preserved in Chalcedony.*

By J. Mac Culloch, M.D. Chemist to the Ordnance, and Lecturer on Chemistry at the Royal Military Academy at Woolwich. V. Pr. Geo. Soc.

IN examining the agates which are found on the shore at Dunglas in Scotland, in the summer of 1811, I was struck with the appearance of organized vegetable substances contained in many of them. It seeming to me impossible that any metallic or earthy matter could put on these forms, I was at some trouble to make a collection of stones exhibiting similar appearances, and to ascertain as far as circumstances permitted, the genera at least of the plants contained in them. The gradual increase and ultimate accumulation of numerous specimens, having enabled me to trace their analogies to plants actually existing, I considered that a detail of the most leading varieties would not be unacceptable to the Society. For the purposes of a more accurate and convenient illustration than the inspection of the specimens alone would convey, I also transmit some enlarged drawings, made by the aid of the microscope, exhibiting the principal varieties.

I did not know when I was first engaged in this investigation that the subject had already attracted attention, and that a detailed account of some well ascertained plants involved in chalcedony had been given by Daubenton.* More lately a letter from Blumenbach has

* Memoires de l'Academie Royale des Sciences, 1782, p. 668.

been quoted in Dr. Thomson's journal, noticing the same fact, and professing the removal of his former doubts. It will be a sufficient apology for not recalling this notice after having thus discovered that the inquiry had not the merit of novelty, that so many should have overlooked, and so many others refused their assent to a fact of no uncommon occurrence.

The metallic arborizations emulating the vegetable form which occur in the fissures of many stones, and the similar well-known figures in the chalcedonies distinguished by the name of mochas, with the lively though superficial resemblance they bear to plants, have led to the hasty conclusion that all these appearances were of a metallic nature, and have probably prevented that accurate investigation of them which they deserved. The want of botanical knowledge has perhaps also assisted in concealing from most mineralogists their true origin, but I may now hope that the possessors of such specimens will hereafter by a more attentive examination confirm the frequency of an occurrence so interesting.

Another circumstance has assisted in this case in deceiving mineralogists, and that is the obscurity in which the vegetable is often involved either by the accidental mixture of metallic oxides in the same stone, or by the actual investment of the whole plant with a thick crust of carbonat of iron. Many of the specimens, and most commonly those which contain confervæ, exhibit at first sight nothing but a confused and entangled fibrous mass of oxide or carbonat of iron. It requires a patient observation to detect in these the existence of a real vegetable structure contained in the stone, and modifying the deposition of metallic matter. It will be found in fact that the whole plant is incrusted with the metallic deposit, and that it exhibits only here and there its true nature. An accurate examination will always detect in these the vegetable disposition, and the sections of the stone will, by cutting through the branches in various oblique directions, lay bare the true structure and distinguish the plant from its adventitious and metallic covering.

A third, and the most common source of deception and obscurity, will be found in the whimsical and fibrous disposition occasionally assumed by chlorite, its colour often imitating the natural hue of a plant as perfectly as its fibrous and ramified appearance does the disposition and form of one. It is by this substance particularly that appearances strongly resembling confervæ are produced, and nothing but a very accurate investigation, with considerable experience in the various forms which this substance puts on, as well as with the aspect and characters of the plants imitated, is sufficient to enable us to distinguish them. In many cases even the most scrupulous attention will fail, a fact which need excite no surprize when it is considered with what difficulty the examination must often be conducted, from a deficiency of light when transmitted through these stones, and from the impossibility of bringing into view any considerable portion of the imbedded substance. Here we must have recourse to the chemical means which I shall presently describe.

It is I believe from the deception to which those specimens have exposed mineralogists, that so much incredulity on the subject exists, every green fibre having been supposed to be chlorite, because it was apparent that chlorite sometimes assumed the form of green fibres. However difficult the distinction, it will be found real, and with sufficient care, generally practicable. The subjoined drawings contain representations of some specimens which are undoubtedly chlorite, and of others which present a very suspicious aspect. Among them however will be found some exhibiting an organization so decided, that no mode of crystallization or inorganic arrangement can be conceived capable of imitating it.

While on this subject it may not be useless to notice the various modifications under which chlorite when mixed with chalcedony presents itself. It is now I believe perfectly well understood (as I have already assisted in showing, in some observations on the island of Rum) that the colouring matter of heliotrope is chlorite diffused uniformly through the mass. From some specimens in my possession, I think it probable that plasma is indebted for its colour to the same substance; the different nature of the siliceous base alone constituting the difference of aspect. In these specimens (brought from Egypt) distinct grains of green matter may be observed independent of the general green stain which pervades the stone; and this probability is rendered still stronger from the colour and appearance which is occasionally assumed by the more transparent flinty matter associated with the chalcedony, the latter acquiring from the chlorite the aspect of heliotrope, while the more transparent parts put on the semblance of plasma. But of a substance so rare it is necessary to speak with hesitation. In quartz the chlorite is well known often to assume a contorted appearance resembling the intestines of animals, but in which the regular crystallization and superposition of the plates can be easily traced. Similarly contorted fibres occurring in chalcedony do not exhibit the crystallized structure, but appear to consist of very minute or of invisible particles, or even of a mere colour diffused in that particular form. At times the coloured fibre contains grains of chlorite attached to its sides or interspersed through its course, thus emulating the imbedded seeds or jointed appearance of real confervæ, and I have reason to think often mistaken for them. I am uncertain whether I should rank under the head of chlorite certain contorted fibres which occur in carnelian, and (though much more rarely) in the agate nodules of trap. These are of a colour sometimes ochry yellow, sometimes white, and sometimes brown. Their forms, so similar to the chlorite fibres, would induce us to class them together, and it is probable that they actually consist of this substance, having undergone some decomposition by which the green colour has become brown, from affections of the metallic colouring matter. It is at present impossible to account for this very singular disposition of the chlorite. In some cases it evidently forms the centre of a fine stalactite, of which the minute ramifications, afterwards preserved in further additions of chalcedony, put on the appearance well known in the green stained chalcedonies of Faroe. But that it is not necessarily stalactitical is certain, from its assuming the very same disposition when existing in quartz crystals. It is probably the result of a species of arborization, that obscure circumstance in crystallization which appears to depend on a sort of polarity between distinct crystals, or throughout the interrupted parts of the same one. Thus water on freezing, and various metallic substances on crystallizing, ramify in certain directions. Thus it will often be found that fibres of mesotype will hold their straight and radiating course across stilbite or other associated minerals, the continuity of direction in the portions of any crystal remaining unchanged, however the crystal itself may be interrupted by obstacles occurring in its course. The same appearance may frequently be observed in quartz and other crystallized substances, and it affords among the various phenomena of the obscure process of crystallization, not the least curious subject of inquiry.

It is in the transparent chalcedonies that the fibrous structures are most visible, but they are also of common occurrence in the opaque ones or agates, as they are usually called, although from the impossibility of transmitting a ray of light through these specimens, our sight of them is limited to that portion which happens to run along the fractured or polished surface. Numerous red, white and yellow agates are every where to be found among collectors and dealers, in which the appearance of fibres is such as to render it very probable that they are portions of vegetables incrusted by oxides of iron, although the obscurity of the specimens must necessarily render this uncertain until they are submitted to chemical trials. If these are vegetable fibres there is no difficulty in accounting for this concealment of the vegetable by the metallic deposit, since it is easy to understand how from a compound solution of flint and iron in water, the iron might first be precipitated on the vegetable, in the same way as we daily see it deposited in chalybeate springs, and how the subsequent deposition of flinty matter might involve and penetrate the whole. It is besides known to botanists, that many plants possess the property of attracting from their state of combination the earthy base of some of the salts which are dissolved in natural waters, a property which may be subservient to some purpose in the economy of the plant, unknown to us. Such is the case with Chara vulgaris, which is always found incrusted with a coating of chalk or calcareous subcarbonate, and such appears also to be the case with Byssus nivea.

It is worthy of remark that in almost all the specimens of chalcedony which appear to contain aquatic confervæ, not only the vegetable structure is perfectly preserved, but the plant, however light and yielding its texture, is disposed in as free a manner as if still living and floating in the water which was its native element. Together with these circumstances, the natural colour is often equally well preserved, and the various specimens of the confervæ in particular, which are the plants of most common occurrence, exhibit all the different tones of colour, from the most brilliant grass green to the darkest sap or lightest yellow green which at present characterize the different living specimens with which we are acquainted. At times however the fibre assumes a whitish aspect, or the yellowish and reddish hue which those delicate plants exhibit when dead, an appearance perhaps even more characteristic of their vegetable nature than their natural colour, since we cannot easily understand how it could be imitated either by chlorite or by metallic oxides.

Botanists who are conversant with the difficulty of ascertaining the species of most of the plants contained in the troublesome class of Cryptogamia, and the uncertainty in particular, which, notwithstanding the meritorious labours of many modern authors, still hangs over the individuals of the genus Conferva, will not be surprized that I have made no attempt to ascertain the species occurring in chalcedonies. They well know the obscurity which attends this pursuit, even where access to numerous examples of the living plant, with the power of turning it in every direction, of viewing it in all its states of growth, and of dissecting it into all its ramifications, facilitate the investigation. With regard to the greater number of species indeed, it is known that no distinction can be traced, nor any accurate character laid down, even by moderate magnifying powers. It is only from those highly magnified views of the living specimen which are capable of exhibiting the peculiarities of its internal structure, and the disposition of its fructification, that characters can be formed or individuals distinguished. This sort of investigation cannot be applied to the remains in question, as the loss of light which necessarily follows the attempt to apply high powers, added to the great diminution of it when transmitted through the chalcedony, entirely deprives us of a sight of them. But in the paper of Daubenton, to which I have already referred, several species are actually described as having been well ascertained; and when we read of two plants in particular, whose characters are so strong and so decided as Lichen digitatus and Lichen rangiferinus, we cannot suppose it possible that he or any other observer could have been deceived. The execution of the plates which accompany his paper has unfortunately not rendered justice to the apparent accuracy of his observations.

It will be seen on inspection either of the specimens or of the drawings, that probably all the plants belong to the Cryptogamia class, and are limited to certain species of them. The explanation of this is sufficiently obvious. It is evident that the siliceous depositions which contain these remains must have been formed in caverns and clefts of rocks, situations only occupied by a few species of this class of plants, and these chiefly Byssi, Confervæ, Jungermanniæ, and the Mosses most commonly so called, plants which require very little light. All the specimens which I have figured will accordingly be found to belong to one or other of these families, with the exception of a few which appear to be fragments of plants, and which I have been unable from their mutilated state to compare with any known species.

It may be asked whether the plants thus preserved are specimens of existing species, or whether they are, like those found entangled in the secondary strata, the remains of a former set of organized beings. The limited number of the specimens which I possess, and the obscurity which attends not only these remains but the present living species, prevents me from attempting an answer to this question on botanical evidence, and on my own knowledge. But the observations of Daubenton appear sufficient to decide that in some instances at least they consist of existing species. Since too the formation of flinty matter by deposition from water is a daily occurrence, there is no reason to doubt that they may be specimens of plants now actually existing. But it is also necessary to consider their geological connexions before a full answer can be given to such a question. This is unfortunately attended with considerable difficulty, as the greater number of specimens are only to be found in the hands of lapidaries and jewellers, in circumstances which render it impossible even to trace the country from whence they have been brought, and much less the geological situations in which they have occurred. I have only one meagre fact to offer on this subject. I have said in the commencement of this paper, that many of the specimens found at Dunglas contain remains of vegetables. These specimens appear to have been detached from a breccia inferior to the lowest sandstone, of which a part is visible at St. Abb's Head, and which is probably a portion of the extensive breccia found in so many parts of Scotland, interposed between the primitive rocks and the whole series of floetz strata. These then contain remains of organized substances of an epocha at least equally ancient with that in which the vegetable remains found in the *floetz* strata existed. As the species ascertained by Daubenton have in all probability been preserved in recent formations of chalcedony, so it is probable that those which I am now describing have been preserved in the chalcedonies of former days.

It is said that chalcedonies of this nature are found in the Dutchy of Deux Ponts, in Siberia, and in other situations, but there is no information sufficiently accurate respecting these on which to ground any reasoning. I ought however, to add, that in many of the Siberian specimens which are known to lapidaries by the name of *Moss agates*, I have ascertained by chemical means that the green fibres consist of chlorite.

It would indeed have been unpardonable not to have used the aids with which chemistry furnishes us to distinguish these obscure substances. Chemical analysis is often the only method by which the very doubtful specimens can be ascertained, and if it be necessary to determine precisely all the specimens which bear the semblance of organization, it is the only trial which can be fully depended on, at least it is the only one on which mere chemical mineralogists will be inclined to place any reliance. A considerable experience in the several substances known by the name of *Moss agates*, combined with some chemical trials on the most leading varieties, and the habits of botanical investigation, may indeed produce that *tact* in this examination which is well known to mineralogists in other cases; a judgment founded on circumstances so evanescent and minute as to be incapable of communication by words. The inconvenience which follows chemical trials is such as necessarily to preclude its application in many instances, and to render it desirable that accurate descriptions of all the varieties could be formed. The destruction of the specimen, often rare and almost always expensive, must inevitably follow this mode of investigation. I have not therefore subjected to this fiery trial every specimen which I have examined, but have selected such a number of the principal varieties as were sufficient to confirm that evidence which had appeared to result from botanical considerations, and to define in most of the difficult cases the obscure boundary between the real vegetable fibre, and its mimic resemblance, chlorite.

The immediate object of chemical trial being to ascertain the presence of carbon in the chalcedony, the two following obvious modes were adopted. It was previously determined that all silicified wood had the property of blackening and decomposing sulphuric acid, and of giving over carbonic acid on distillation with nitre. It was also ascertained that chlorite (*chlorite baldogée* or green earth) did not possess the first of these properties, and that neither of these effects resulted from thus treating common chalcedony. Previously to these trials the precaution was also taken of boiling the specimens for a considerable time in a solution of pure potash, to remove in the polished ones all possibility of the adhesion of the lapidary's oil, a circumstance which would inevitably have led to fallacious results. In these experiments ample confirmation appeared of the deductions which had been made from botanical examination, and I was further enabled to detect many specimens of chlorite, where I had not suspected its existence. The same trials afforded a test which I found in many instances to be very easily applicable to the object of this distinction. This test consisted in the effervescence which is produced when boiling sulphuric acid is applied to those chalcedonies which contain chlorite, while those which contain vegetable fibres blacken the same substance without exciting effervescence. I need scarcely add that I laid no stress on the method of distillation when the stone appeared to contain carbonat of iron. It was not necessary to examine into the cause of the effervescence produced by the action of the sulphuric acid on the chlorite, a circumstance on which the very uncertain and contradictory analyses of Meyer, Höpfner, and other chemists throw no great light.

It would be a waste of time to attempt a description of the character of each individual stone which is found to contain a vegetable substance. However desirable it might be to find a specimen attached to its native place of growth, it has not, as I have before remarked, yet occurred to me, nor do I find that it has occurred to any of those who have noticed the same facts. Yet the appearance of many of the chalcedonies which contain well ascertained specimens of plants, is such as to render it likely that they do now occur *in situ.* Many of the specimens, and among others those which contain the hypnum figured at No. 7, have the mammillated appearance which implies that they have been formed by the stalagmitic process. And in these the plant is broken, compressed, and deranged, though it preserves its natural colour. In many others no mechanical texture or disposition can be discovered in the stone, but the whole appears one semitransparent mass of chalcedony. These are the specimens in which the confervæ preserve that freedom of arrangement and that perfection both of colour and structure which seem to imply that they had been so suddenly involved in a mass of siliceous matter as to have been preserved from all future changes. Many other specimens have that mixed aspect of jasper and chalcedony to which among other varieties of ornamental stones the lax term of agate has been applied. In some specimens we may observe that zoned appearance which so generally characterizes the chalcedonies occupying the basaltic geodes, the zones always respecting the various parts of the plant, and forming round it parallel, angular, or curved figures. From this we may infer that the zoned disposition of those chalcedonies which go by the name of onyxes, may as well have proceeded by a successive deposition from the centre towards the circumference, as in the reverse order, an arrangement supposed by some mineralogists to have been the cause of this structure in the nodules found in trap.

The fact of the existence of entire vegetable remains in chalcedony being thus established, it may be said that it is analogous to the well-known instances of silicified wood, and of animal remains similarly situated. Yet it offers some important differences which may throw light on certain disputed points, and lead to conclusions of no small consequence, conclusions not so universally resulting from those facts. It has been maintained on one hand that the silicification of wood and of animal remains might have been the result of silex injected in a state of igneous fusion. I know not that it is necessary for the theory which offers this explanation, that this solution should be admitted, since the existence of that theory is not necessarily implicated in the universal proof of this supposition. It will scarcely be asserted that substances of so tender a structure as those I have described, substances so evidently involved in siliceous matter while freely exposed to light and air, could have undergone this change by any process of compression connected with igneous fusion. Nor could any theorist invent a scheme of this nature which should involve the remains of a land animal, so fragile as is that chrysalis of an insect figured in the plate No. 29, with so little change of structure. A watery solution of silex seems so indispensible for this purpose, that it is superfluous to insist upon it. Of such watery solutions there are abundant examples existing, examples which it is unnecessary to quote; but the instances under examination offer to our consideration views still more wide and more interesting, however difficult their explanation may be. It is plain on reviewing some of the cases above described, that a process different from the tedious one of infiltration and gradual deposition, must have produced the appearances in question. Neither the free disposition nor the forms of the delicate vegetable structures could have been preserved during so slow a process, nor could their colour have remained unaltered. The loss of colour must have followed the death of the plant, and the total loss of its figure would have resulted from the gradual changes which it must needs have undergone during the continuance of a process so tedious. The remains are in fact (if I may use such an expression) embalmed alive. To produce this effect, we can only conceive a solution of silex in water, so dense as to support the weight of the substance involved, a solution capable of solidifying in a short space of time, or capable at least of suddenly gelatinizing previously to the ultimate change by which it became solidified into stone. I need not point out the extreme importance of this supposition, I had almost said of this fact, to any general theory of the earth. It is for chemistry yet to investigate experimentally the mode of imitating this unknown process. Those who know the present state of this science will not hesitate to admit its imperfections, and those who have attended to its rapid progress will not despair.

Description of Figures. Pl. 36. 37.

No. 1. I think the peculiar membranes and defined structure seen in this figure can only arise from a plant, although I am not acquainted with any analogous living vegetable. I had not enough to subject it to chemical trial.

2. This figure exhibits one of the most common forms in which chlorite is disposed in chalcedonies, a form not very likely to mislead an observer.

3. I have figured this for the purpose of shewing the remarkable imitation of a conferva, which may be produced by chlorite; that part of the drawing which is most highly magnified, exhibiting a chain which consists of distinct scales of this substance.

4. Is drawn from a specimen which appears to contain fragments of two plants; a conferva, and the leaves of some other plant, perhaps a moss.

5. That this drawing is made from a plant, I have ascertained by chemical trial, and the green spots which seem disseminated along the fibre are probably the fructification.

6. This specimen exhibits an internal structure, not very unlike

that of conferva ægagropila, although its size is such as to preclude it from belonging to this species, not to notice the other important distinctions between them.

7. The seventh figure exhibits the decided character of a moss, and probably of a hypnum: I have selected two of the most entire branches, the greater number having the leaves folded and confused, as if by external force, a circumstance in itself important. Fibres, appearing to be those of a conferva, may be observed in the same stone, which is a transparent chalcedony, with the mammillated appearance that determines it to have been a stalagmite.

8. A larger specimen of a plant very like No. 6.

9. Very delicate fibres of chlorite, but much resembling the conferva tortuosa. They were ascertained to be chlorite by the chemical means already described.

10. The pale colour which surrounds the dark line in this figure, appears to arise from some metallic crust, investing a simple fibre.

11. In this figure nothing but a reticulation of minute yellow fibres can be discerned, and it is to a similar disposition of fibres that a great proportion of the red and yellow agates owe their colour. I believe that this particular description of agate has never been suspected to contain vegetable fibres, nor to owe the disposition of its colouring matter to the effect of these fibres in modifying the deposition of iron. The agates of this tribe generally exhibit a muddy uniform yellow colour; at times, though more rarely, a lively red, and are very common among lapidaries. It is only when in thin plates, and by the assistance of transmitted light, that the existence of fibres is detected in them. When subjected to the action of sulphuric acid they blacken and decompose it in the way I have before described.

12. This figure is intended to convey a notion of the mode in which oxides of iron invest the vegetable fibre.

13. Exhibits a remarkable instance of a deposit of reddish oxide of iron, modified by a white central fibre, with whose nature I am unacquainted.

14. I suspect that this consists of grains of chlorite, become brown from some of the changes to which I alluded in the paper, and surrounded with an additional metallic covering.

15. The ramified structure of this is too decided to admit of its being any thing but a vegetable substance ; possibly it is the root of some moss.

16. In the chalcedonies, which go by the name of Mochas, brown arborizations are known to be very common, and often to assume appearances which render these stones much sought after for ornaments. I have here figured one which bears so strong a resemblance to the imbricated Jungermanniæ, that it is difficult at first sight to distinguish them. The detached scales render the deception still stronger, their appearance being that of leaves which have been broken off. But it will I believe be found that all these are metallic. How much soever, the bases or middle parts of the pretended plants may put on an appearance difficult to discriminate, it will almost always be found that the extremities of the branches are undefined and shapeless, while in the Jungermanniæ the regular imbrication of the scales is continued to the minutest extremity. The eye of a botanist will also with care discover an irregularity in the superposition of the scales, which never occurs in the plants themselves, and a decision in the setting on of the branches in the real plants, which is ill imitated by the clumsy way in which the ramifications are disposed in the metallic arborization. I do not however mean to deny that these stones may not contain organized bodies, as I have below given a figure of such an one.

17. Fibres, very common in chalcedonies, and bearing a considerable resemblance to Byssus nigra,—conferva ebenea of Dillwyn.

18. Fibres of a brown colour, with whose nature I am unacquainted. They are possibly vegetable, but I had not enough to apply the chemical test to the specimen.

19, 20, 21. Were drawn for the purpose of shewing various coloured fibres which are among the most common of those found in chalcedonies. The generally great decision and character of their ramifications seem to establish them as vegetable fibres, and which, as I observed in the paper, have lost their colour by the process of death going hand in hand with their lapidification.

22. Appears to consist of fragments of a lichen of the foliaceous imbricated kind, akin to centrifugus and saxatilis, and bearing a considerable resemblance in colour and general appearance to Parmelia Borreri, as figured in the Linnean Transactions. The fragments are too insufficient in extent, and too deeply bedded in the stone to admit of any very accurate judgment respecting their affinities.

23. Is another example of a moss, apparently of the same family with that figured at No. 7. I have drawn it precisely as it appears. It differs from the former in the more orbicular and obtuse form of the leaves. It is contained in a large nodule of chalcedony, which exhibits much colour and the zonular disposition.

24, 25, and 26. Brown ramified fibres of the same apparent nature as 19, 20, and 21. For these drawings I am indebted to Mr. Blore, and they are from specimens in his possession which I have not had an opportunity of examining very particularly.

27. These are contained in an oriental chalcedony or mocha. They are evidently hollow tubes, of which various aspects are exhibited by the chance section of the stone.

28. Similar tubular bodies which appear equally to belong to the same class of beings. I have figured these because they had been

supposed by some of my friends to be examples of the fact under review. They appear to belong to the tribe of Zoophytes.

29. The singularity of this occurrence has induced me to give a figure of it. I know not indeed that any other example than the present one has been produced of an animal substance of this nature preserved in chalcedony. The stone which contains it is a striped onyx agate, and is part of a ring in the possession of the Earl of Powis. Its fortuitous section by the lapidary has exposed the internal as well as the external side of the chrysalis, from which the fly had escaped previously to its lapidification. Its structure points it out to be the pupa of a lepidopterous insect, probably of a moth.

30. I have figured this, although I conceive it to be another example from the Zoophytes, because I suspect that it has been mistaken for the fructification of a moss.

It is proper to remark that the figure attached to each specimen is intended to express the number of times it is magnified in the drawing.

Independently of the figures which I have now given, I possess numerous other varieties, which I thought it superfluous to represent, as they afforded no striking peculiarities. I have chosen the figures among the most perfect, as well as among the most obscure, for the purpose of illustrating the one by the other; and I have also added the mimic resemblances to guide, if possible, the investigations of others, and to prevent them from attributing too much to any bias which might be supposed to have warped my own observations.

XXIV. *On the Vitreous tubes found near to Drigg, in Cumberland.*

Compiled by the Secretaries from several Communications.

IN the hillocks of drifted sand, which lie between the mouth of the river Irt and the sea near to Drigg, in Cumberland, hollow tubes of a vitreous substance were discovered rising above the surface perpendicularly through the sand.* They were found three in number, within an area of fifteen yards, upon a single hillock, about forty feet above the level of the sea. The diameter of each was about an inch and a half. An excavation being made around one of them, it was found to descend perpendicularly through the sand about thirty feet. At the depth of about twenty-nine feet the sand was interrupted by a bed of pebbles, appearing to be the continuation of the sea-beach. The tube here came in contact with a fragment of hornstone-porphyry, glanced off from it at an angle making about 45° with the horizon, and then returned to its former vertical position. Below this fragment the tube, becoming extremely delicate, was frequently broken; and at the distance of a foot, during

* The first notice of these substances was transmitted to the Society in the year 1812 by E. L. Irton, Esq. of Irton Hall, in Cumberland, and was accompanied by specimens. This gentleman removed the sand from around one of the tubes to the depth of 15 feet. Messrs. Greenough and Buckland, Members of the Society, examined the sand hills in company with Mr. Irton in the autumn of the year 1813, and finding the surface lowered more than 15 feet by drifting since the year 1812, resumed the excavation. The observations of these three gentlemen are introduced into the present paper.

an attempt to recover it, the sand fell in and prevented further investigation. The lowest part of the last piece, that was detached, was not closed, and did not exhibit any peculiarity of structure, from which it could be inferred that the extremity had been reached. The tube appears to have tapered in its descent, its diameter at the bottom of the excavation being reduced to half an inch. One specimen in the collection of the Society is bi-furcated; whence it is probable, that the stem was divided into two branches, one of which may have escaped observation. Small lateral branches proceeded from different parts of the stem, not exceeding two or three inches in length, nor a quarter of an inch in diameter at the points of insertion. They were conical, and ended in points, gradually bending downwards. Internally they were hollow, and opened into the principal duct, which, except in dimensions, they perfectly resembled.

The outside of the tube is coated with an agglutinated sand, which viewed with a lens is found to consist of black and opaque white grains mixed together, and rounded, as if by incipient fusion; the white grains, when farthest from the centre of the tube, having a reddish tint. The stem is irregularly angular, like a vegetable stalk much contracted by drying, and is rugged with deep longitudinal interrupted furrows, like the bark of the elm or of the cork tree. The sides of the tube are about the twentieth part of an inch thick, and are very hard and rigid.

On proceeding inwards, their substance gradually loses the appearance of sand, and becomes vitreous, the whole interior being covered with a smooth glaze. This vitrified matter is whitish or limpid, containing specks of a dark olive colour and a few air blebs. It is sufficiently hard to scratch glass.

The irregular form of the interior surface corresponds to that of the exterior, and the whole tube has the appearance of being creased by compression, while in a soft state. The opposite sides of a crease are often brought into contact and welded together, and thus the tube is sometimes so flattened as to be entirely closed. In this way the irregular furrows on the outside have been produced.

The tube on touching the pebble of hornstone porphyry above mentioned, was welded to it; but on the side adjacent to the pebble the substance of the tube was wanting, and in the place of it was found an unglazed rust-coloured mark, passing across one of the flat faces of the stone. In parts of this mark thin laminæ were standing up from the surface, and two small patches of an olive coloured glass were adhering to the edges of two natural fissures in the pebble.*

Since the substances that have been described had all the marks of fusion, it was not improbable that they might be imitated by submitting to the action of heat the sand and the pebble with which the tube came in contact. With this view the following experiments were made.

A fragment of the pebble, of a greenish slate colour, heated to a dull red before the blowpipe, became rust-coloured, and when urged by a strong flame, was melted into an olive-coloured glass, similar to that observed on the surface of the pebble.

The sand of which the hillocks are composed, viewed through a lens, appears to consist of grains of white or reddish quartz, mingled with a few grains of hornstone porphyry.† The latter, when picked out of the sand, are fusible before the blowpipe like the pebble of the same substance, but they are not in sufficient quantity to act

* A similar appearance is noticed by Saussure (1153) on the Dome de Gouté, and is by him referred to the action of lightning. The pebble above mentioned is in the cabinet of the Society; the adhering tube was unfortunately broken off in its way to London.

† A few fragments of shell are also to be seen here and there.

as a flux on the entire sand heated in the usual manner. The sand so treated is reddened in the first instance, changes afterwards to an opaque white, and finally is very slightly agglutinated, resembling in its shades of colour and in its cohesion that which adheres to the outermost coating of the tube.

The sand was exposed to the flame of a spirit lamp, urged by a stream of oxygen gas, in which flame Dr. Marcet has shewn that a thick wire of platina may be melted. The grains of hornstone porphyry first began to flow, and presently acting upon the grains of quartz, formed a clear glass mingled with portions of an olive colour. Even thus however the fusion was partial, and the utmost intensity of the flame was required to support it.

The glass thus formed resembled that of the tube in its external characters, in being very hard and difficult of fusion, and in containing a great excess of siliceous matter: for it was ascertained that a fragment of the tube was scarcely softened at the edges by the same flame that had melted the sand; and that the substance of the tube contained a large portion of silica, had been determined by one of the members.

From what has been stated, it appears that the tubes have all the marks of fusion, and that their substance can be imitated in some measure by subjecting the sand to intense heat. That they are of very recent date is certain from the shifting nature of the sand hillocks in which they are found, and from their inability to remain alone and unsupported by the sand without breaking. Lightning seems to be the only agent that could at once supply the heat and the force requisite to make them. In the familiar experiment of perforating a quire of paper by the Leyden battery, a mechanical effect of electricity analogous to the present is exhibited, and instances of fusion by the same instrument it is not necessary to enumerate.

The sand hillocks of Drigg, though of inconsiderable elevation, are not unfavourably situated for promoting a discharge, since they present themselves as the first and highest object in front of the marshes of the Irt to clouds coming from the sea. Should the explanation of the Sand Tubes, which is now offered, be admitted, some judgment may be formed of the intensity of the heat developed in great electrical explosions.

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	Mineral Conchology, No. 4, 5; by Jas. Sowerby.	The Author.
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	Geological Travels. 3 vols. 8°	. . . . . .
	History and Analysis of the Mineral Waters at Butterby, near Durham; by W. R. Clanny, M.D. 8°	The Author.
Nov. 5.	Outlines of the Mineralogy of the Ochill Hills; by Charles Mackenzie, Esq. 8°	The Author.
	Annals of Philosophy; by Dr. Thomson. N° 6, 7, 8, 9, 10, 11. 8°	The Editor.
	Journal de Physique, in continuation, to April 1813. 4°	Robert Ferguson, Esq. Vice. Pres. G. Soc.
	Geological Travels in France and Germany; by J. A. de Luc. 2 Vols. 8°	The Author.
Dec. 3.	Report of the Volcanos of Guadaloupe.	Rev. I. Gilding, Memb. G. Soc.
	Manuscript Memoir on the Solfaterra of Guadaloupe.	. . . . . .
	Statistical Survey of the County of Donegal; by James Mac Farlan. 8°	J. F. Berger, M.D. Memb. G. Soc.
	Statistical Survey of the County of Londonderry; by the Rev. V. Samson. 8°	. . . . . .
	Reports on the Tavistock Canal.	J. Taylor, Esq. Memb. G. Soc.
17.	Traité Elémentaire de Physique; par M. Haüy. 2 Vols. 8°	J. F. Berger, M.D. Memb. G. Soc.
	Introduction to the Irish Language; by the Rev. W. Neilson. 8°	. . . . .

1813.	DONATIONS.	DONORS.
Dec. 17.	Letter on Zeolite; by Dr. Richardson.	J. F. Berger, M.D. Memb. G. Soc.
	British Testacea; by W. Maton, M.D. and the Rev. T. Rackett. From the Transactions of the Linnean Society. 4°	......
	Lettrés Philosophiques sur les sel et les crystaux; par Bourguet.	G. B. Greenough, Esq. Memb. G. Soc.
1814. *Jan.* 7.	Annals of Philosophy; by Dr. Thomson. N°13. 8°	The Editor.
	London Medical Repository. N° 1. 8°	The Editors.
21.	Zoologia Adriatica dell abate Giuseppe Olivi. 4°	Hon. Henry Grey Bennet, Pres. G. Soc.
1814. *Feb.* 18.	Letters on Sicily; by W. Irvine, M.D. 8°	J. F. Berger, M.D. Memb. G. Soc.
	Annals of Philosophy; by Dr. Thomson. N°14. 8°	The Editor.
	Essai d'une nouvelle Minéralogie; par M. Wiedman. 8°	G. B. Greenough, Esq. Vice Pres. G. Soc.
	Dictionaire Universelle des Fossiles; par M. Bertrand.	......
	Tractatus Physicus de Petrifactis; a Johanne Gesner. 8°	......
Mar. 4.	Mineral Conchology; by J. Sowerby. N° 6, 7, 8 & 9. 8°	The Author.
	Description of the Eruption of the Souffriere of St. Vincent.	Rev. J. Gilding.
18.	Charpentier on the Geology of Upper Saxony.	J. H. Vivian, Esq. Memb. G. Soc.
	——————— of Lower Saxony.	......
	Transactions of the Royal Society of Edinburgh. Part 1. Vol. 7. 4°	Royal Society of Edinburgh
	Transactions of the Asiatic Society. 11 Vols. 4°	Asiatic Society.
	Journal de Physique, for May, June, July, and August, 1813	R. Ferguson, Esq. Memb. G. Soc.
April 1.	Fossilia Hantoniensia; by G Brander. 4°	H. Warburton, Esq. Sec. G. Soc.
	Petrificata Derbiensia; by W. Martin, F.L.S. 4°	Lord Compton, Memb. G. Soc.
15.	Epistolæ Physiologicæ; a Leuwenhoek.	S. Parkes, Esq. Memb. G. Soc.
	Elenchus Tabularum Pinacothecarum, &c. Levini Vincent. 8°	......
	Storia naturale delle Provincie del Reale Collegio Fernandiano. 8°	......
	Jordan on Mineral Waters. 8°	......
	Sepulcretum Westphalico-Minigardico Gentile.	......
May 6.	Practical Navigator; by J. Moore. 8°	J. F. Berger, M.D. Memb. G. Soc.
	Postchaise Companion through Ireland.	......
20.	An Account of the Basalts of Saxony, with Observations on the origin of Basalt in general; by J. F. Daubuisson. Translated, with Notes, by P. O'Neill, F.R.S & F.L.S.	P. Neill, Esq. Sec. Wern. Nat. Hist. Soc.
	Memoirs of the Wernerian Society, vol. 2. part 1.	The Wernerian Society.

1814.	DONATIONS.	DONORS.
June 3.	Annals of Philosophy; by Dr. Thomson, N° 15, 16, 17, 18. 8°	The Editor.
	Journal des Mines from the commencement to the present time. 8°	L'Administration des Mines de la France
17.	A Manual of Mineralogy; by Arthur Aikin, Sec. to the Geological Society. 8°	The Author.
	Specchio delle Scienze o Giornale. Enciclopedico di Sicilia. Palermo, 1813. 8°	The Editors.
	Traité Elémentaire de Minéralogie, par M. Brogniart 8°	H. Warburton, Esq. Sec. G. Soc.
	Regenfuss on Shells fol.	. . . . .
	Appendix to Aikin's Chemical Dictionary 4°	W. Phillips, Esq. Memb. G. Soc.
	Practische Gebirgskunde von I. C. Voigt, 4°	W. Sheffield, Esq.
	Journal de Physique, in continuation to February, 1814. 8°	R. Ferguson, Esq. Memb. G. Soc.
	Seven books on Mineralogical Subjects.	M. Etter.

II. *Donations to the Collection of Maps, Sections, &c.*

1811.		
	View of the Soufriére of Guadaloupe, by Mons. Coussin, jun.	N. Nugent, M.D. Hon. Memb. G. Soc.
Dec. 6.	Drawing of the rock of Stirling Castle, and Map of the United States of America.	G. B. Greenough, Esq. Pres. G. Soc.
20.	Drawing of the disturbance of some Coal Strata, six miles south-east of Hexham.	Rev. W. Turner, Hon. Mem. G. Soc.
	Section shewing the mode of blasting rocks at Newcastle.	. . . . .
	Section of the Strata at Coalcleugh, Alston Moor.	. . . . .
	Plan of the Mines at Alston Moor.	G. B. Greenough, Esq. Pres. G. Soc.
1812.	Section of the Strata at Allon Heads near Alston Moor.	Thomas Crawhall, Esq.
Jan. 17.	Drawing of Curvatures in the Killas near Plymouth.	J. MacCulloch, M.D. Memb. G. Soc.
	Drawing of Limestone Strata at Chepstow.	. . . . .
	Drawing of a Curvature in the Coal Strata in the Coalfield at Tenby.	. . . . .
	Sections of the Strata at Bradford, near Manchester.	Robert Bakewell, Esq.
	Sections of Strata at East Rainton Colliery.	John Buddle, jun. Esq. Hon. Memb. G. Soc.
	- - - - - at Engine pit, Percymain Colliery	. . . .
	- - - - - at Wall's end F. pit.	. . . . .
	- - - - - at Engine pit, Willingworth.	. . . . .
	- - - - - from the High main to the Low main coal seam, at Charlotte pit, Walker colliery.	. . . . .
	- - - - - at Coxlodge.	. . . . .

1812.	DONATIONS.	DONORS.
	Sections of Strata at Hepburn B. pit.	John Buddle, jun. Esq. Hon. Memb. G. Soc.
	- - - - at Gateshead Fell.	. . . . .
	- - - - at Bigges main Colliery.	. . . . .
	- - - - at Lanchester Common.	. . . . .
March 6.	Diagram of the Triangles of the Trigonometrical Survey of Great Britain.	J. MacCulloch, M.D. Memb. G. Soc.
	Map of England, with a sketch of the Mountains	W. Conybeare, Esq.
	Drawings of Alcyonia, in the Isle of Wight.	Thomas Webster, Esq. Memb. G. Soc.
	Drawings of a Vein in a Lime Stone.	J. Mac Culloch, M.D. Memb. G. Soc.
June 19.	Ordnance Map of Kent.	E. W. Rundell, Esq. Mem. G. Soc.
	Drawing of Meteorolites.	James Sowerby, Esq. Mem. G. Soc.
Nov. 6.	Nine Maps of England with the principal Strata sketched in.	G. B. Greenough, Esq. Pres. G. Soc.
Dec. 4.	Sundry Sections and Plans accompanying Mr. Phillips's paper on the Veins of Cornwall.	William Phillips, Esq. Mem. G. Soc.
18.	Two Drawings of the junction of the Sandstone and Greenstone in the rock of Stirling Castle.	J. MacCulloch, M.D. Mem. G. Soc.
	A Plan of the Vitrified Fort of Dun MacSniochan.	G. B. Greenough, Esq. Pres. G. Soc.
	Three Perspective Views and a Plan of different parts of Switzerland.	
	A vertical Section of the Strata in the Forest of Dean.	David Mushet, Esq. Hon. Mem. G. Soc.
	Section of Horbeck stone pit at Wilsford, in Lincolnshire.	Sir A. Hume, Bart. V. P. G. Soc.
1813. *Jan.* 1.	Six Maps and Plans with a Description of the Great Copper mine at Fahlun in Dalecarlia.	S. Solly, Esq. Treasurer, G. Soc.
15.	Map of the Azores.	W. Conybeare, Esq. Mem. G. Soc.
	Map of the Caledonian Canal.	. . . . .
	Nine Maps of various parts of Sweden and Norway.	S. Solly, Esq. Treas. G. Soc.
Feb. 19.	Gardner and Yeakell's Map of Sussex.	A. Apsley, Esq. Mem. G. Soc.
	Nine Drawings of the Rocks of Clovelly.	Rev. I. J. Conybeare, Mem. G. Soc.
	Plans and Sections of the Ashover denudation.	J. Farey, Esq.
	Drawing of the Rocks at Lydstop.	J. Mac Culloch, M.D. V. P. G. Soc.
April 2.	Section of the Strata at Darlstone Bay, Dorsetshire.	T. Webster, Esq. Keeper of the Mus. G.S.
	Engraved View of Handfast Point, Dorsetshire.	Sir H. Englefield, Bart. V. P. G. Soc.
23.	Map and Section of the Isle of Man.	J. F. Berger, M.D. Mem. G. Soc.
May 7.	Ten Geological Drawings of Parts of Scotland.	J. MacCulloch, M.D. V. P. G. Soc.
21.	Fourteen Prints of Geological Subjects.	G. B. Greenough, Esq. Mem. G. Soc.

1813.	DONATIONS.	DONORS.
June 18.	Drawing of a Curvature in Lias, near Shepton-Mallet.	Rev. Wm. Conybeare, Mem. G. Soc.
	Seven Drawings of Rocks on the Coast from St. Agnes to Cligga point	Rev. I. J. Conybeare. Mem. G. Soc.
	General Sections of the Isle of Wight and of Alum Bay.	T. Webster, Esq. Keeper of the Mus. G.S.
Nov. 19.	Map of the County of Wicklow.	J. F. Berger, M.D. Mem. G. Soc..
	Two Drawings of Undulating Veins of Granite and Quartz.	J. MacCulloch, M.D. V. P. G. Soc.
	Drawings of the Clay Cliffs of Sheppey, and of a Chalk-pit at Northfleet.	T. Webster, Esq. Keeper of the Museum G. Soc.
Dec. 3.	Nineteen Maps of the North of Europe.	M. Etter.
	M.S. Map of the County of Donegal.	Earl of Londonderry
	M.S. Survey of the Malvern Hills.	Lieut. Colonel Mudge Mem. G. Soc.
	Hydrographical Survey of the West Coast of Ireland	J. F. Berger, M.D. Mem. G. Soc.
17.	Fennin's Map of the Isle of Man.	. . . . .
	Arrowsmith's Map of Ireland.	. . . . .
	Rocque's Map of the County of Dublin.	. . . . .
1814.		
April 1.	Baugh's Map of Shropshire.	Hon. H. Grey Bennet, Pres. G. Soc.
May 20.	Sections of the Strata at Jacob's Whim Shaft, Arkindale.	A. Carlisle, Esq. Mem. G. Soc.
	Diagram of throws and protrusion of schist into a vein.	. . . . .
	Section of Belton Shaft near Blanchland.	. . . . .
June 3.	Sections and Drawings of the Pentowan Stream Works, near St. Austle, Cornwall.	Edward Smith, Esq.

III. *Donations to the Cabinet of Minerals.*

1811.		
Nov. 1.	Specimens of the Strata at Folkestone.	Robt. Ferguson, Esq. Vice Pres. G. S.
	Crystallized Sulphate of Barytes from Cumberland.	. . . . . .
	Collection of Specimens from the Isle of Man.	J. F. Berger, M.D. Mem. G. Soc.
	Specimens from the neighbourhood of Weymouth.	James Laird, M.D. Sec. G. Soc.
	Specimens of Toad-stone, &c. from Micklewood, in Gloucestershire.	G. Cumberland, Esq. Memb. G. Soc.
	Series of Specimens from the neighbourhood of Bristol.	R. Bright, Junr. Esq. Memb. G. Soc.
	Specimens of Sulphur from the Souffriére of Montserrat, and of specular Iron Ore from Guadaloupe.	N. Nugent, M.D. Hon. Memb. G. Soc.
	Jasper Agate from Palermo.	. . . . . .
	Specular Iron Ore from the Lipari Islands.	W. Franklin, M.D. Memb. G. Soc.

Date	DONATIONS.	DONORS.
1811.	Specimens from Dinmore-hill, in Herefordshire.	Henry Warburton, Esq. Memb. G. Soc.
	Slab of Limestone with Organic Remains from Charmouth.	G. B. Greenough, Esq. Pres. G. Soc.
15.	Specimens from the Island of Bourbon.	A. Aikin, Esq. Sec. G. Soc.
	Specimens from the Alum mine of Hurlet, near Paisley.	J. Ridout, Esq. Memb. G. Soc.
Dec. 6.	Sulphat of Strontian from Knaresborough.	James Sowerby, Esq. Memb. G. Soc.
	Specimen of Witherite from Shropshire.	A. Aikin, Esq. Mem. G. Soc.
	Specimens from Yorkshire and Cumberland.	G. B. Greenough, Esq. Pres. G. Soc.
	Series of Specimens from Allonheads, Alston Moor	Thomas Crawshall, Esq.
20.	Specimen from Warwickshire.	Leon. Horner, Esq. Sec. G. Soc.
	Specimen of Witherite from Merton Fell, Westmoreland.	J. G. Children, Esq. Memb. G. Soc.
	Specimen of Pure Clay from Halle, and of Melanite from Frascati.	A. Champernowne, Esq. Memb. G. Soc.
1812.	Specimens of Fossil wood from the Tunnel at Blisworth in Northamptonshire.	Ch. Harvey, Esq. Memb. G. Soc.
Jan. 17.	Specimens of Vegetable Remains on Coal Slate from Somersetshire.	W. James, Esq. Memb. G. Soc.
	Part of a hollow ball of Ferruginous Sandstone from a hill 400 miles east of the Cape of Good Hope	W. Richardson, D.D. Hon. Memb. G. Soc.
Feb. 21.	Specimens from Northumberland.	Hon. H. G. Bennet. Memb. G. Soc.
	Specimens from Ireland.	G. B. Greenough, Esq. Pres. G. Soc.
	Specimen of supposed Native Lead from Holywell, North Wales.	T. R. Jones, Esq.
Mar. 20.	Series of Corundum from China and India.	Sir A. Hume, Bart. Vice Pres. G. Soc.
	Septarium from Hertfordshire.	. . . . . .
	Specimen of undescribed Alcyonium from Brighton.	Sir H. Englefield, Bart. Mem. G. Soc.
April 3.	Specimen of Statuary Marble rendered elastic by heat.	J. Mac Culloch, M.D. Memb. G. Soc.
	Iron Ore from Botany Bay.	. . . . . .
	Specimens from Labrador.	Rev. Mr. Latrobe.
	Specimens of Slickenside.	A. Champernowne, Esq. Memb. G. Soc.
	Specimens of the Nautilus nummularia, from Egypt, Spain, &c.	James Sowerby, Esq. Memb. G. Soc.
	An undescribed Fossil Shell from Shropshire.	. . . . . .
	Specimens from the Paris mine in Anglesea.	A. Aikin, Esq. Sec. G. Soc.
	Specimen of Garnet Rock from Huntly, in Banffshire	. . . . . .

1812	DONATIONS.	DONARS.
Apr. 17.	Specimens in illustration of Dr. Mac Culloch's paper on Bitumen.	J. Mac Culloch, M.D. Memb. G. Soc.
	Specimens in illustration of Mr. Horner's paper on Droitwich.	L. Horner, Esq. Sec. G. Soc.
	Specimen of Fibrous Rock Salt from Northwich.	A. Aikin, Esq. Sec. G. Soc.
May 1.	Specimens of Calcareous Spar from Tavistock.	J. Taylor, Esq. Memb. G. Soc.
	Specimen of recent Pentacrinus from Guadaloupe.	Joseph Skey, M.D.
	Specimens of the Aluminous Strata from Campsie.	C. Mackintosh, Esq.
15.	Specimens from Derbyshire.	W. Milnes, Esq. Hon. Memb. G. Soc.
	Specimens of Magnesian Limestone from Sunderland.	Sir A. Hume, Bart. Vice Pres. G. Soc.
June 5.	Series of Corundum, Oriental Ruby, and Spinelle.	Count de Bournon, Foreign Sec. G. Soc.
	Specimens of the Calcaire d'eau douce, and of the Meuliere d'eau douce from the neighbourhood of Paris.	. . . . . .
	Specimen of Hippurites from Cape Passaro in Sicily.	Hon. H. G. Bennet, Memb. G. Soc.
	Specimens of Alcyonia from the Isle of Wight.	T. Webster, Esq. Keeper of the Mus. G.S.
19.	Specimens of Tubes found in the sand at Drigg in Cumberland.	E. Irton, Esq.
	Series of Specimens from Vesuvius.	Hon. H. G. Bennet, Memb. G. Soc.
	Specimens of Chalk with Fossil Palates from Cherry Hinton.	H. Warburton, Esq. Memb. G. Soc.
	Specimens from Barbadoes.	Joseph Skey, M.D.
	Specimens from Yorkshire.	. . . . . .
	Specimens from Alderney.	Capt. Richardson, 63d Regiment.
	Specimen of Coral from the East Indies.	Capt. Loch.
	Specimens from Mount Sorrel in Leicestershire.	H. Warburton, Esq. Memb. G. Soc.
June 5.	Large Fossil Vertebra from Dry Sandford, Berkshire.	Rev. W. Buckland.
	Specimens from France, Hungary, Siberia, &c.	H. Heuland, Esq. Mem. G. Soc.
Nov. 6.	Specimens in illustration of Dr. MacCulloch's paper on the Vitrified Forts.	J. MacCulloch, M.D. Mem. G. Soc.
	Specimens from Leicestershire.	Robert Bakewell, Esq.
	Specimens of the Sand tubes from Drigg.	E. L. Irton, Esq.
	Specimens from North America.	Dr. Bruce.
	Specimens of Flint from Norfolk.	H. Reeve, M.D.
	Specimens from Bristol.	G. Cumberland, Esq. Hon. Mem. G. Soc.
	Specimen of Carbonate of Lead from Shropshire.	Thomas Dugard, M.D. Hon. Mem. G. Soc.
	Specimen of Asbestos and of black Chalk from Ireland.	Rev. T. Hincks, Hon. Mem. G. Soc.

Date	DONATIONS.	DONORS.
1813. *Nov.* 20.	Specimens from Sicily.	James Franck, M.D. Mem. G. Soc.
	Specimens of Coal and Greenstone from Walsall in Staffordshire.	A. Aikin, Esq. Sec. G.S.
	One Ton of Coals from Wyken near Coventry.	Wm. James, Esq. Mem. G. Soc.
	One ditto from Pelsall, Staffordshire.	. . . . .
Dec. 4.	Specimens from Cornwall.	Rev. I. J. Conybeare, and Rev. Wm. Buckland.
18.	Specimens from Ireland and Scotland.	J. MacCulloch, M.D. Mem. G. Soc.
	Specimens of Cobalt ore from Alderley edge, Cheshire.	Rev. E. Stanley.
1814. *Jan.* 1.	Fossil Shark's teeth from Malta.	Capt. Beaufort, Hon. Mem. G. Soc.
15.	Specimens from Sweden.	S. Solly, Esq. Treas. G. Soc.
	Specimens from Cornwall.	Rev. J. J. Conybeare, and Rev. J. Buckland.
Feb. 19.	Specimens from South America, from Cheshire, and Somersetshire.	T. Meade, Esq. Hon. Mem. G. Soc.
	Specimens illustrating the junction of Greenstone and Sandstone, Stirling Castle.	J. MacCulloch, M.D. V.P. G. Soc.
	Organic Remains illustrative of Mr. Parkinson's paper on the Strata near London.	James Parkinson, Esq. Mem. G. Soc.
	Specimens of Jet from Whitby, and of Agate from Scotland.	Right Hon. Lord Dundas, Mem. G. Soc.
	Specimens of Organic Remains from Shropshire.	Hon. H. G. Bennet, Pres. G. Soc.
	Specimens from Cornwall.	Rev. I. J. Conybeare, Mem. G. Soc. and Rev. Wm. Buckland.
	Crystallized Felspar and Bituminous Marle Slate.	A. Champernowne, Esq. Mem. G. Soc.
	Siliceous Petrifactions, from Tisbury, Wiltshire.	Miss Bennett.
March 19.	Specimens from Rutlandshire and Harrowgate.	H. Warburton, Esq. Mem. G. Soc.
	Organic Remains from Hordwell Cliff, Hampshire.	Miss Bennett.
	Specimen of Calcareous Incrustation found in the pipe of a steam engine.	Hon. H. G. Bennet, Pres. G. Soc.
	Specimens from Dorsetshire and the Isle of Wight.	Sir H. Englefield, Bart. Vice Pres. G. Soc.
April 23.	Specimen of Chalcedony, from Charmouth.	Rev. Wm. Buckland, Memb. G. Soc.
	Siliceous Petrifactions of Corals, from Antigua.	N. Nugent, M.D. Hon. Memb. G. Soc.
	Specimens from the neighbourhood of Paris.	Hon. H. G. Bennet, Pres. G. Soc.
	Fossils from the Crag Pits, Aldborough, in Suffolk.	H. Warburton, Esq. Memb. G. Soc.
	Specimens of Volcanic Ash, from the Island of Bourbon.	Sir Gilbert Blane, Bart. M.D.

1813.	DONATIONS.	DONORS.
April 23.	Specimen of Actynolite, from Cullen Point.	Rev. W. Serle, Memb. G. Soc.
	Slate, with Organic Remains, from Tintagel, Cornwall.	Rev. I. J. Conybeare, Memb. G. Soc.
May 7.	Specimen of Euclase, from Brazil.	E. W. Rundell, Esq. Memb. G. Soc.
	Specimen of Topaz and Apatite, St. Michael's Mount, Cornwall.	S. Solly, Esq. Foreign Sec. G. Soc.
21.	Specimens of Zeolites, from Ferroe and Perthshire.	Leonard Horner, Esq. Sec. G. Soc.
June 4.	Specimens from the Archipelago.	Wm. Mac Michael, M.D. Memb. G. Soc.
	Specimens from Cambridgeshire.	H. Warburton, Esq. Memb. G. Soc.
	Specimen of native Arsenic, from the Hartz.	A. Champernowne, Esq. Memb. G. Soc.
18.	Specimens, containing Organic Remains, from the summit of Snowdon.	Rev. J. Hailstone, Woodwardian Prof. Memb. G. Soc.
	Specimens of Tremolite, from Clicker Tor, Cornwall.	Rev. W. Gregor, Hon. Mem. G. Soc.
	Specimens from Huel Maudlin Mine, Cornwall.	W. Rashleigh, Esq. Memb. G. Soc.
	Volcanic Specimens from the Rhine, and Minerals from Sweden	S. Solly, Esq. Treasurer G. Soc.
	Specimens of simple Minerals.	H. Heuland, Esq. Memb. G. Soc.
Nov. 5.	Specimens of a supposed Fossil Crocodile, from Charmouth	G. B. Greenough, Esq. Memb. G. Soc.
	Specimen of Organic Remains, from Wiltshire, Hampshire, and Dorsetshire.	Miss Bennett.
	Specimens of Zeolitic Amygdaloid, from Ferroe.	T. Allan, Esq.
	Specimen of Calcareous Spar, from Shropshire.	T. Dugard, M.D.
19.	Fossil Wood, from the Isle of Portland.	G. Cumberland, Esq. Memb. G. Soc.
	Nummulites, from Selsea.	James Parkinson, Esq. Memb. G. Soc.
	Large Crystal of Felspar, from Catharineberg, in Siberia.	H. Heuland, Esq. Memb. G. Soc.
	Specimens and Fossils illustrative of Mr. Webster's Paper on the Strata above the Chalk.	T. Webster, Esq. Keeper of the Mus. G.S.
Dec 3.	Specimen of Strata and of Organic Remains.	B. Bevan, Esq. Hon. Memb. G. Soc.
	Organic Remains from Corwen, in North Wales.	O. Tudor, Esq. Memb. G. Soc.
	Specimens of Granite and Gneiss, from North Wales, Westmoreland, and Leicestershire.	G. B. Greenough, Esq. Memb. G. Soc.
	Specimens from Glen Tilt, in Aberdeenshire, illustrative of his paper.	J. Mac Culloch, M.D. Vice Pres. G. Soc.
	Specimens from Russia.	M. Etter.
17.	Specimens from Cornwall.	Rev. I. J. Conybeare, Memb. G. Soc.

1813.	DONATIONS.	DONORS.
	Specimens from Lauren Hill, Galloway.	Rev. Wm. Buckland, Memb. G. Soc.
	Specimens of Strata and Organic Remains illustrative of his paper	T. Webster, Esq. Keeper of the Mus. G.S.
1814.		
Jan. 7.	Specimens of Siliceous Petrifactions, from Antigua.	N. Nugent, M.D. Hon. Memb. G. Soc.
	Specimens of Shells in Marl, from Fifeshire.	H. Warburton, Esq. Memb. G. Soc.
	Specimens of Flints from the London Gravel.	T. Webster, Esq. Keeper of the Mus. G.S.
	Specimens of Brazilian Topaz.	Hon. H. G. Bennet, Pres. G. Soc.
31.	Specimens from Guadaloupe.	Rev. J. Gilding, Memb. G. Soc.
	Specimens of Pitch Stone from the Hebrides, and of Strata from the Coal Field of Fifeshire.	G. B. Greenough, Esq. Memb. G. Soc.
	Specimen of Corundum, from Gellivara, in Swedish Lapland.	M. Swedenstierna, Hon. Memb. G. Soc.
	Specimens from Northumberland and Roxboroughshire.	Hon. H. G. Bennet, Pres. G. Soc.
	Specimens from the Vale of the Tweed.	H. Warburton, Esq. Memb. G. Soc.
Feb. 18.	Nodule of Iron Stone.	Royal Society.
	Specimens from Scotland.	H. Warburton, Esq. Sec. G. Soc.
	Specimens of English Rocks.	. . . . .
	Specimens of English, Scottish, and Irish Rocks.	G. B. Greenough, Esq. Vice Pres. G. Soc.
March 4.	Specimens from Palermo.	Hon. H. G. Bennet, Pres. G. Soc.
	Fossil Nautilus and Crystallized Selenite.	A. Sutherland. M.D. Memb. G. Soc.
	Specimens from Petworth and Mount Sorrell.	Wm. Blake, Esq. Vice Pres. G. Soc.
	Specimens of Puddingstone from Hemel Hempstead.	H. Warburton, Esq. Sec. G. Soc.
	Specimens of Coal and Coal Slate, from Sweden.	Rev. Wm. Buckland, Memb. G. Soc.
	Specimens of Magnesian Limestone, &c. from Cumberland.	G. B. Greenough, Esq. Vice Pres. G. Soc.
	Specimens of Molybdena in Granite, from Shap, in Westmoreland.	Wm. Lowndes, Esq. Memb. G. Soc.
18.	Specimens from Northumberland.	Hon. H. G. Bennet, Pres. G. Soc.
	Fossils from English Strata.	Miss Bennett.
April 1.	Vein Stones from English Strata.	G. B. Greenough, Esq. Vice Pres. G. Soc.
	Specimens of simple Minerals.	W. Sheffield, Esq. Memb. G. Soc.
	Fossil Shells arranged systematically.	James Parkinson, Esq. Memb. G. Soc.

1812.	DONATIONS.	DONORS.
April 1.	Specimens illustrative of Mr. Taylor's section of the Tunnel of the Tavistock Canal.	J. Taylor, Esq. Memb. G. Soc.
15.	Specimens of English and Scottish Rocks.	G. B. Greenough, Esq. Vice Pres. G. Soc.
	Specimen of Labrador Felspar.	O. Tudor, Esq. Memb. G. Soc.
May 6.	Specimens of Fossil Wood and recent Shells.	S. Turner, Esq. Memb. G. Soc.
	Specimen of White Marble from Strath, in the island of Sky.	J. Mac Culloch, M.D. Vice Pres. G. Soc.
	Alcyonia from Stokenchurch Hill, Oxfordshire.	Rev. P. Serle, Memb. G. Soc.
10.	Specimens from Hudson's Bay.	Earl of Selkirk, Memb. G. Soc.
	Sulphate of Strontian, from Bristol.	G. Cumberland, Esq. Hon. Memb. G. Soc.
June 3.	Fossil Belemnites from Bosworth, Leicestershire	B. Bevan, Esq. Hon. Memb. G. Soc.
	Specimens from the Geyser spring, and other Minerals, from Iceland	H. Holland, M.D. Memb G. Soc.
	Specimens & Organic Remains, from Stonesfield, Oxfordshire.	Hon. H. G. Bennet, Pres. G. Soc. Lord Compton, Memb. G. Soc. G. B. Greenough, Esq. Vice Pres. G. Soc.
	Specimens from the Pentowan Stream Works, near St. Austle, Cornwall.	Edward Smith, Esq.
	Fossils from Cambridgeshire.	Rev. J. Hailstone, Woodwardian, Prof. Memb. G. Soc.
	Fossils from Cambridge.	H. Warburton, Esq. Sec. G. Soc.
	Fossil Belemnites.	C. Stokes, Esq. Memb. G. Soc.
	Fossil Bones and Specimens, from the Basin of Paris.	G. B. Greenough, Esq. Vice Pres. G. Soc.
	Specimens of Chrysocolle, from the Vale of Newlands, near to Keswick.	W. E. Sheffield, Esq. Memb. G. Soc.

IV. *Apparatus.*

1813.		
Nov. 5.	A Clinometer.	Lord Webb Seymour, Memb. G. Soc.

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